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POLLUTION OF LAKE SUPERIOR AND ITS TRIBUTARY BASIN, MINNESOTA-WISCONSIN-MICHIGAN. PROCEEDINGS OF CONFERENCE HELD AT DULUTH, MINNESOTA, ON MAY 13-15, 1969. VOLUME 3

Federal Water Pollution Control Administration
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PROCEEDING

Volume 3

LAKE SUPERIOR
MINNESOTA
MICHIGAN
WISCONSIN

May 13-14-15, 1969
Duluth, Minnesota
Executive Session
September 30-October 1, 1969
Duluth, Minnesota

CONFERENCE

Pollution of Lake Superior and Its Tributary Basin, Minnesota-Wisconsin-Michigan

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(May 15, 1969, Morning Session)

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PROCEEDINGS

May 15, 1969

MR. DOMINICK: Ladies and gentlemen, I believe the clock on the wall is slow so we will get started now. Will you take your seats, please.

I will repeat the wish of the Chairman of the conferees that we complete all of the testimony for this first Lake Superior conference today, and that all testimony which we receive be as brief and as original in nature as possible.

We will proceed first on our agenda with the State of Michigan.

MR. PURDY: Mr. Chairman, I would like to call on Mr. William Turney to present the statement. Mr. Turney will not read the report in its entirety, but we ask that it be placed in its entirety in the record. He will briefly go through it.

MR. DOMINICK: Without objection, that will be done.

STATEMENT OF WILLIAM G. TURNEY,
MICHIGAN WATER RESOURCES COMMISSION,
DEPARTMENT OF NATURAL RESOURCES,
LANSING, MICHIGAN.

MR. TURNEY: Mr. Chairman, conferees, ladies and gentlemen:

W. G. Turney

The report is entitled "Report on Water Pollution Control in the Michigan Portion of the Lake Superior Basin and Its Tributaries, Prepared and Published by the Michigan Water Resources Commission, of Department of Natural Resources and the Michigan Department of Public Health," at the Conference Called by the Secretary of the Interior on Pollution of Waters of Lake Superior and Its Tributary Basin.

This report contains information on the municipal and industrial waste disposal situation in the Michigan portion of the interstate waters of Lake Superior and in the tributaries to Lake Superior in Michigan. It delineates the statutes that provide the local units of government authority to build, own, and operate waste treatment facilities. It delineates the accomplishments that have been made in controlling pollution and the measures that are being taken to provide improved control. It also describes the uses being made of these waters and water quality conditions.

The report was prepared for presentation to the conferees at the Federal conference called by the Secretary of the Interior for their consideration and appraisal in (1) arriving at conclusions as to whether waste discharges originating from Michigan sources are endangering the health or welfare of persons in a State other than that in which the discharge or discharges originate, (2) determining the adequacy of measures that have been taken for abatement of pollution, and (3) determining the nature of delays, if any, being encountered in abating pollution.

The area encompassed by the report includes all of the Michigan portion of Lake Superior and its tributaries.

W. G. Turney

All sources of municipal sewage and industrial waste discharges to surface waters are covered. The nature of waste treatment or control measures in effect are described and the State agency action to control pollution and evaluate accomplishments is related.

The files and records of the Michigan Water Resources Commission and the Michigan Department of Public Health are the sources of information contained in the report. The employed staffs of both agencies collaborated in assembling the material and preparing the report.

Chapter I, Statutory Authority, Michigan Law Relating to Water Pollution Control

List A includes 19 State acts. A. Authority for local units of government to build, own, and operate waste treatment facilities.

List B contains 25 State acts giving authority for the control of water pollution.

Michigan's Clean Water Bond Program

In November 1968 Michigan electors, by a three-to-one margin, authorized the sale of $335 million worth of bonds for purposes of assisting communities in improving existing and constructing new waste treatment plants; $50 million of this total bond program is to be used for sewer construction assistance for communities without sewers which are contributing to an existing pollution problem and have low property valuation.

Implementing legislation is now being developed by the legislature and proposed bills have been introduced. One would amend

Act 329, Public Acts of 1966, to provide a State grant of 25 percent of the cost of construction of treatment works eligible for Federal participation under Public Law 84-660 and to advance one-half of the Federal grant if Federal funds are not available. A second bill provides State grants to assist local agencies in the construction of collecting sewers. This grant would be for 50 percent of the cost of construction of collecting sewers in excess of 10 percent of the State equalized value of all taxable property within the political boundaries of the unit served.

Also on Page 6 is an abstract of the Attorney General's Opinion No. 4590 on authority of the Water Resources Commission to regulate copper and iron mining operations.

The 1965 amendments to Michigan's basic pollution control law, Act 249 of 1925, cast a cloud over our Water Resources Commission's authority to regulate copper and iron mine tailing resources. The Attorney General's opinion included, among other things, a statement that copper and iron mining operations are subject to the protective provisions of the Water Resources Act.

Chapter II, State of Michigan Pollution Control Program

Administration of water pollution control functions in Michigan necessarily follows the division of statutory responsibility set forth in the previously cited statutes subject to correlation, wherever possible, of member department interests and objectives with those of the Water Resources Commission. The Water Resources Commission and the Department of Public Health and their respective staffs carry the principal burden of water pollution control in Michigan at the State level.

W. G. Turney

Water Resources Commission Pollution Control Program

Goal:

The objective of the Michigan Water Resources Commission is to bring all existing unlawful pollution under continuing effective control and prevent the development of unlawful pollution from new sources, population growths, or increased industrial expansion and, where such incidents occur, limit their duration and intensity to the fullest extent consistent with requirements of the Water Resources Commission statute. Under the Michigan statute (Appendix A) it is unlawful for any person directly or indirectly to discharge into the waters of the State any substance which is or may be injurious to the public health, safety, or welfare; or which is or may be injurious to domestic, commercial, industrial, agricultural, recreational, or other uses which are being or may be made of such waters, or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life or plants, or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired. The discharge of any raw sewage of human origin, directly or indirectly into any waters of the State, is prima facie evidence of a violation of the statute unless such discharge is permitted by an order, rule, or regulation of the Water Resources Commission.

Action Regarding Inadequacies

Where inadequacies in control of waste discharges are determined to exist, and opportunity is provided for establishment of voluntary corrective action. When it appears to the Michigan Water Resources Commission that a voluntary program will not be successful or may not be accomplished within a reasonable time period, statutory procedures are initiated. Orders adopted contain specific effluent restrictions and specific dates for approval of construction plans and specifications, awarding of construction contracts and commencement of construction, and the completion of construction and attainment of pollution abatement as required by the order.

Combined Sewerage Systems

New sewerage systems must be developed on the basis of separate sewers for storm water and sanitary wastewater. When at all feasible, separated sanitary wastewater systems shall not be discharged into combined systems. If such discharge does occur, control facilities must be developed on the combined system so as to protect present and future water uses of the receiving waters consistent with the requirements of the Water Resources Commission statute. Problems associated with the overflow of storm and sanitary waste from existing combined public waters must be corrected on or before June 1, 1977.

Nutrients in Municipal and Industrial Waste Discharges

Nutrient discharges, particularly with respect to phosphates, to public waters must be controlled. Persons proposing to make a new or increased use of waters of the State for waste disposal purposes are required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and as a long-term objective, all existing waste dischargers will be required to provide facilities for the removal of phosphorus compounds by June 1, 1977. See Page 17 for further discussion.

W. G. Turney

Watercraft Pollution Control

The discharge of sanitary waste from recreational watercraft will be controlled by rules and regulations adopted by the Water Resources Commission on February 22, 1968, with an effective date of January 1, 1970. Complete rules are contained in Appendix B of the report.

Control of New Waste Discharges

The Michigan Water Resources Commission will prevent the development of new problems by continued implementation of Section 8 (b) of its statute which required the filing of a statement of use by any person proposing to make a new or substantial increase in use of waters of the State for waste disposal purposes. The Commission, upon receipt of a statement, makes an order stating such minimum restrictions as may be necessary to guard adequately against unlawful uses of waters of the State.

Water Quality Standards

Water quality standards and use designations for all inter- (Appendix C) and intrastate (Appendix D) waters have been adopted. Water use designations, together with a plan of implementation and enforcement of the standards, were adopted for interstate waters on June 28, 1967, while the intrastate water standards were adopted on January 4, 1968. The use designations for intrastate waters were established on March 20, 1969. A series of five water and related land resource inventory reports were compiled by the staff of the Water Resources Commission and were used, along with other supporting data, as background material for determining use designations.

W. G. Turney

Certain intrastate waters are not at present designated for specific uses. The Water Resources Commission did not designate uses for waters receiving discharges from the copper and iron mining industries pending an Attorney General's opinion as to the authority of the Commission to regulate mining wastes. This opinion has now been received and, consistent with the Commission rules, a public hearing is scheduled in August 1969 at Escanaba, at which time use designations will be considered for these waters. Adoption of use designations by the Commission is expected within 60 to 90 days following the hearing.

On interstate waters, where noncompliance with the standards is determined to exist as the result of a discharge from an existing municipal wastewater treatment plant, treatment facilities adequate for meeting established water quality standards must be provided no later than June 1, 1972. Secondary treatment is required as a minimum unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with present and future water uses. Industrial waste discharges must meet the same treatment requirements as municipal waste effluents, and industrial waste problems identified in the interstate plan reports must, no later than June 1, 1970, have adequate treatment or control facilities.

Inspection and Facility Approval

The Water Resources Commission staff inspects each incipient pollution problem regularly. All orders now adopted by the Commission to both industries and municipalities require routine analysis and reporting of the quality of wastes discharged to public waters. In addition, surface water quality and waste effluents are monitored so as to identify the approach of pollutional conditions in time to initiate appropriate corrective action prior to the development of a statutory injury. The Water Resources Commission staff reviews and approves or rejects plans for industrial waste treatment or control facilities and counsels with management on industrial waste treatment or disposal problems. It develops appropriate restrictions and time schedules for Commission approval to correct or prevent pollution problems, and participates in enforcement procedures initiated by the Commission through statutory hearings and enforcement of Commission orders in court when voluntary compliance is not forthcoming.

Mandatory Certification of Industrial Treatment Plant Operators

Act 209, Public Acts of 1968, requires that all industrial or commercial establishments discharging liquid wastes into the waters of the State shall have waste treatment facilities under the specific supervision of persons who have been certified by the Water Resources Commission as properly qualified to operated the facilities. It further requires that monthly operating reports shall be filed with the Commission, showing the effectiveness of the treatment facility operation and the quantity of the wastes discharged.

Implementation of this program is now under formulation by the Commission with assistance by an industrial management advisory committee.

W. G. Turney

Data Processing

The Michigan Water Resources Commission is now developing data storage and retrieval systems. Full consideration is being given to the systems now employed by the Ontario Water Resources Commission and the United States Government so as to afford easy exchange of data and cooperative use of the three systems. Reporting forms are in the final stages of preparation and the entire system will hopefully be operational in about 3 years.

Department of Public Health Pollution Control Program

The Department of Public Health, acting through its Division of Engineering, exercises supervisory control over all public sewerage systems. The director of the department is required by statute, Act 98, Public Acts of 1913, as amended, to "exercise due care to see that all sewerage systems are properly planned, constructed, and operated so as to prevent unlawful pollution of the streams, lakes, and other water resources of the State." The companion statute, Act 245, Public Acts of 1929, as amended, defines unlawful pollution and authorizes the Water Resources Commission to "establish such pollution standards for lakes, rivers, streams, and other waters of the State in relation to the public use to which they are or may be put, as it shall deem necessary." Such pollution standards and the water quality criteria relating to the public uses, recently approved for both interstate and intrastate streams, provide the framework upon which decisions are made and actions taken in relation to the planning, design, construction, and operation of all sewer systems and treatment works. Elements of this supervisory program include the following:

W. G. Turney

Facilities Planning and Approval

1. Review engineering reports establishing the basis of design for projects involving collection and treatment of wastewater and consult with the engineers and municipal officials on elements of the proposed design prior to development of plans and specifications for the project, require modification of proposed design where appropriate and, when found to be satisfactory, approve same.

2. Review, approve, or reject and secure changes in plans and specifications submitted for new municipal systems or for changes in existing systems, both for collection and treatment.

3. Conducts inspections to determine that construction of public sewerage systems conforms to approved plans and specifications.

4. Require reduction of overflows from existing combined sewer systems. Adoption of accelerated programs for effective control of overflows from such systems is strongly urged. Progress has been made in several communities such as Houghton, Munising, and Marquette.

5. Require municipal rather than private ownership of all sewerage systems serving the public.

6. Counsels with officials of municipalities and their consulting engineering agents as to the need and methods for collection and treatment of wastewater.

7. Strongly encourage and, where appropriate, require the development of multicommunity area planning to provide effective services and pollution control facilities utilizing sound management principles. Many such areas are currently served by an integrated system of sewers, interceptors, and treatment works. Others are being

so planned in several areas. Examples are Houghton, Hancock, and Marquette.

8. Encourage the admission of industrial wastes in municipal sewerage systems where such wastes will not adversely affect the system and its performance in relation to effective pollution control.

9. Foster, encourage, and assist communities in the adoption of effective and practical sewer use ordinances for the control of industrial wastes to be admitted to the sewerage system.

10. Encourage and, where appropriate, require communities to conduct studies, pilot or plant scale, to provide a dependable basis of design for unusual combinations of industrial and municipal wastes to be treated where sufficient information is not available for design purposes.

11. Encourage and assist communities to conduct studies to establish effective methods for removal of phosphates from their wastes at existing treatment works. In the last year, several communities have purchased spectronic equipment and are obtaining background data on phosphates in their wastes. Some are doing bench scale tests on phosphate removal with iron and aluminum salts. These plants include Ironwood, Ontonagon, Houghton-Hancock, and Marquette.

12. Require facilities for removal of phosphates in the design of new treatment works, consistent with the adopted policy of the Water Resources Commission.

13. Require expansion and improvements of municipal facilities, both for collection and treatment as present capacity is approached,

rather than wait until the facilities are overloaded before taking action. Approval of sewer extensions is withheld where additional loadings would exceed the capacity of the system until an acceptable program for relief is officially adopted. "Sewer bans" have been imposed in such circumstances, such as at Laurium. Authority for such action has been tested and upheld in the courts.

14. Order changes in facilities or their operation when requirements of the statutes have not been met. Alternatively, cases involving deficiency in facilities are referred to the Water Resources Commission for action.

15. As agent for the Water Resources Commission, review, approve or reject plans submitted for new sewer systems, other than municipal.

16. Assist and encourage local health departments to effectively direct and control the installation of private sewage disposal systems where public sewer systems are not available for connection.

17. Require construction of separate sanitary sewers for new community systems.

Facility Operation - Supervison, Visitation

1. Require the effective operation of all treatment works, including pumping stations and sewer system appurtenances.

2. Require all municipalities to submit reports monthly on the operation of treatment works.

3. Supervise operation by on-site inspection, instruction and consultation with plant operating personnel. Adequate services of this nature require visitation once during each 3 months on the average.

Privately-Owned Public Sewerage System Policy

1. Require private developers of public sewerage facilities to obtain authorization and approval from the township board as to all related matters as required by the constitution, applicable laws, and local ordinance.

2. Require a plan for the effective and continuous operation of the facilities by the owner.

3. Require a resolution by the township board that it will assume complete responsibility for the effective operation and maintenance and make any necessary repairs, replacements, extensions, or improvements to the facilities which are required in the public interest if the private owner should fail to do so. (Complete text of the policy is in Appendix F).

Operator Certification and Training

1. Require all municipalities to employ operators whose competency has been certified by the Department. Over 600 operators have been so certified on the basis of education, experience, and written examinations.

2. Conduct formal group training sessions to impart specific information related to effective operational control, to provide opportunity for exchange of information and experience, and to provide incentives for self-study and development. Over 325 operators attend a 2-day meeting each year conducted by Department engineers and chemists. A series of four 5-day sessions in laboratory procedures involving chemical and bacteriologial analyses have been conducted concurrently

with four 5-day sessions in colorimetry by the Department staff during January and February the past 2 years; 225 operators who presently perform such tests at their plants registered for these short courses. Evening courses are held throughout the State for a 12 week period in mathematics, chemistry or hydraulics as applied to wastewater works operation, in a cooperative program with other agencies and organizations. Special courses in process control safety, and related areas are sponsored with other groups.

3. Encourage operators to meet on a regular schedule, usually about once monthly, on their own initiative to exchange information on plant operational problems and experiences.

Disinfection Policy and Practice

1. Require all municipalities to disinfect the plant effluent on a year-round basis before discharge to the surface waters of the State. This policy was adopted in January 1967 (Appendix G). Virtually all communities in the State are conforming to this policy.

2. Require the provision of adequate facilities and their operation, monitoring and testing in such a manner as to assure continuous effective disinfection.

3. Require regular reporting on forms furnished by the Department of chlorine used daily, results of chlorine residual readings, and related information. Most communities are performing bacteriological analyses on the chlorinated effluent as a check on the chlorine dosage and chlorine residual regimens. Other small communities are currently planning to apply additional refinements in control this year.

W. G. Turney

Studies on Removal of Phosphorus from Wastewater at Municipal Treatment Plants

During the past 2 years studies have been made by several Michigan municipalities on removal of phosphorus from the wastewater collected in their community sewer systems. Two general methods were utilized: one involving the addition of metal salts either to the raw sewage or activated sludge with or without the addition of polymers; the other involving management of the activated sludge process without chemical additions.

A variety of study methods and procedures were followed. Some involved bench studies only, using jar tests on the wastes undergoing treatment at the plant; others included full-scale plant operation applying the knowledge acquired in the bench work; and others were conducted at pilot plants built to establish a basis of design for facilities to be added.

The first of these studies was conducted at Grayling, a resort community of less than 2,000 resident population. Bench studies indicated that 80 percent or more of total phosphorus could be removed from the raw wastes by plain sedimentation with the addition of 15-30 mg/l of ferrous chloride as iron, 30-50 mg/l of sodium hydroxide as equivalent calcium carbonate, and about 0.5 mg/l of an anionic polymer.

Work of a similar nature, both in bench studies with jar tests and full-scale plant operation, was performed at the Village of Lake Odessa. Here the municipal treatment facilities include trickling filters and sludge digestion facilities. The same chemicals were applied to the raw sewage as at Grayling in about the same concentration, except that the dosage rates of the ferrous chloride were less effectively controlled, resulting in rather widely fluctuating dosage rates, ranging from daily averages of about 15 mg/1 to 60 mg/1. No mixing or flocculation equipment was installed. Wastes varied widely from day to day and week to week in strength and quantities by reason of changing admixtures of wastes from a food processing plant. Total period of the palnt scale study, both with and without chemical treatment, was 86 days, including 33 days when valid operating data were obtained under controlled chemical feeding conditions. These date generally confirmed Grayling observations, although removal of total phosphorus, 5-day BOD and suspended solids by primary sedimentation was somewhat lower.

Other work involving use of ferrous chloride and polymers was performed in 1967 at the Village of Whitehall and the city of Traverse City. The studies thus far have been bench scale, employing jar tests similar to those at Grayling and Lake Odessa. Results have generally confirmed the earlier findings at the other two plants.

Rather extensive studies of phosphorus removal by metallic ion precipitation in a biological system have been conducted since September 1967 at the municipal activated sludge plant of the city of Warren. A pilot plant was installed as the first step in a study to establish a basis of design for extending the present capabilities of the plant to meet an effluent requirement of 8 mg/1 20-day BOD and 80 percent removal of total phosphorus.

It has been demonstrated in daily operation and testing that:

1. Total phosphorus precipitated by metallic ions were removed by activated sludge in the order of 70 percent or higher consistently, and an additional 10 percent or more was removed by the rapid sand filters.

2. The addition of iron or aluminum directly in the mixed liquor for phosphorus removal is compatible with the activated sludge process when operated for high-degree BOD removal.

Other work of a pilot nature has been conducted by the cities of Detroit and Trenton for the past year and a half under demonstration grants from the Federal Water Pollution Control Administration. Both projects utilize activated sludge and Detroit also is investigating trickling filters. Data obtained will be used for the design of formal facilities to be added to the existing primary plants for improved treatment, including phosphorus removal.

At the Benton Harbor-St. Joseph activated sludge plant, a 30-day study on full plant operation indicated removal of about 90 percent total phosphorus using ferrous chloride and a polymer, both applied ahead of primary sedimentation.

Studies have been made at the Lansing activated sludge plant of the effect of varying concentrations of pickling liquors in the raw sewage on removal of phosphorus in the system. Similar studies are in progress at the Jackson activated sludge plant.

Water Resources Commission's Policy on Phosphate Removal

The Water Resources Commission's pollution control program concerning phosphate removal was established in October 1967 when the following policy was adopted:

W. G. Turney

Whereas, nutrients released to our water environment are a contributing factor to an accelerated rate of aging of inland lakes and streams, including the Great Lakes, as evidenced by growths of aquatic weeds and algae; and

Whereas, phosphorus is an essential element to such growth;

THEREFORE BE IT RESOLVED, that persons proposing to make a new or increased use of waters of the State of waste disposal purposes will be required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and that as a long-term objective, all existing waste discharges will be required to provide facilities for the removal of phosphorus compounds by June 1, 1977.

Construction Grant Program

The Commission maintains a grant administrator whose responsibilities include assisting municipalities in all phases of the construction grant program. Prospective applicants are advised of State and Federal grant programs currently in effect for sewage treatment works, are advised where to obtain and file applications, and are kept advised of all program developments of importance. Under administrative rules of the Commission, grants are allocated by the administrator according to priority points assignment. The administrator also certifies projects to the State Treasurer, serves as intermediary between the city and the Federal Water Pollution Control Administration for Federal grants, and makes inspections of grant projects.

No financial assistance for maintenance of pollution control facilitites is provided by the State. Technical assistance is provided by the Department of Public Health, Division of Engineering. Instruction in maintenance of specific pieces of treatment plant equipment is provided through the Department's operator training program.

The State also provides for the exemption of water pollution control facilities from certain taxes.

Chapter III, Discharges to Surface Waters

Industries

The Water Resources Commission staff has under surveillance 21 industries which discharge wastewater to public waters in the Lake Superior Basin. The 21 industries that discharge waste effluents to surface waters are listed in Appendix I, together with their pollution status rating, type of treatment provided, waste effluent data, where such is available, and formal abatement action taken by the Commission. The pollution status ratings are updated annually and represent the Water Resources Commission's staff effort to fairly appraise each incipient pollution problem as indicated by a review of operating reports, observations, inspections or surveys during the preceding calendar year. The ratings are by letter code as follows, ranging from A to E. You may notice this adds up to 27 instead of 21, some industries having more than one outlet and being rated more than once.

A. Control adequate

B. Control provided - adequacy not established

C. No control - need not established

D. Control provided - protection unreliable

E. Control inadequate

(Table 1 and Table 2 follow:)

TABLE 1

Pollution Status Rating	Type of Industry			
	Chemical	Paper	Electric Power	Total
A			4*	4
B	1	1		2
C				
D				
E				
Total	1	1	4	6

* This figure represents two power companies, each with two ratings. As shown by the table, all four industries have either an A or B rating.

TABLE 2

SUMMARY OF INDUSTRIAL SURFACE WATER DISCHARGES IN THE LAKE SUPERIOR BASIN

April 1, 1969

Pollution Status Rating April 1, 1969 / River Basin	Montreal	Black	Presque Isle	Mineral	Ontonagon	Sleeping	Portage	Sturgeon	Falls	Dead	Carp	Chocolay	Au Train	Two Hearted	Taquamenon	Waiska	Minor Drainage Areas	Total
A				1	1				3		3							8
B	2	1		1	1	1	3				1	1			1		4	16
C																		
D																		
E					1					2								3
Total	2	1		2	3	1	3		3	2	4	1			1		4	27

Note: Eighteen industries are reflected here; one industry has six ratings, one has three and two have two ratings. One industry also has a discharge to Lake Superior.

W. G. Turney

There are four industries which have effluent discharges directly to Lake Superior, 18 have effluent discharges to inland surface waters tributary to Lake Superior (Marquette Board of Power and Light discharges to both Lake Superior and the Dead River). The pollution status ratings for these industries are summarized by tributary river basins in Table 2. As shown in the table, three have E ratings.

Governmental Units

The 41 governmental units that discharge waste effluents to public waters are listed in Table 1, Appendix J, together with the type of treatment provided, waste effluent data where such is available, abatement action taken, and present status. The data was obtained from records of the Michigan Department of Public Health and the files of the Water Resources Commission. Nearly all of the waste effluent data reflect averages for the month of September 1968. Only one municipality, Baraga, discharges wastewater directly into Lake Superior. The remaining 39 discharge to various tributaries inland from the lake.

The 41 municipalities in the basin had a 1964 estimated population of 98,945 people. Ten of these municipalities, with 40.4 percent of the total population, are serviced by secondary biological processes. The remainder of this paragraph is modified. Twenty-three municipalities are considered to be discharging improperly treated sewage into the waters of the State. Of these 15 have engineering studies or plans under preparation. Eight communities have been notified that approved treatment is required and voluntary performance schedules and programs are now being formulated for these eight communities. Of the 23 communities, 14 have populations between 50 and

500 people. Eight have populations between 500 and 1,500. There is one community with a population of 3,000. These are all relatively small communities.

Interstate River Basins

The Michigan portion of the Lake Superior Basin has only one interstate stream, the Montreal River. Industrial and municipal waste discharges within the Montreal watershed are listed below and in Appendices I and J.

MUNICIPALITY	INDUSTRY
Erwin Twp.	Superior Packing Co.
Ironwood	William E. Maki Slaughterhouse
Ironwood Twp.	

The three municipalities had an estimated population of 10, 780 people in 1964, all of which are served by secondary waste treatment facilities. In keeping with the Michigan Department of Public Health policy on disinfection of sewage treatment plant effluents (Appendix G), Ironwood and Ironwood Twp. provide year-round chlorination. Erwin Twp., however, being served by septic tanks and tile filters, does not disinfect their sewage effluent. Flow data and waste characteristics are not available for the two industries in the basin; however, both are served by primary waste treatment facilities.

Federal Installations

There are 12 Federal installations which discharge waste effluents into surface water in the Michigan portion of the Lake Superior Basin (see Appendix K). In keeping with Commission's requirements on phosphorus removal, staff has recommended that facilities to meet this requirement be provided at the two major Air Force Bases (Kincheloe and K. I. Sawyer) in the basin. Four of the installations are light stations (one is a former light station) with raw or semi-treated sewage discharges directly into Lake Superior. The Michigan Water Resources Commission has recommended and is currently awaiting alleviation of these problems. Treatment is considered adequate at the other six Federal units in the basin.

I would also like the record to show, as has been mentioned earlier, Michigan receives monthly operating reports from its wastewater treatment plants. Although the Department of Public Health has requested that it be furnished operational reports from the Federal waste treatment plants, the Federal Government has not seen fit to comply with these requests. For this reason we have not been able to fully evaluate the effectiveness of these facilities or to give the degree of professional guidance that is afforded to other municipalities and industrial waste disposal treatment plants in Michigan.

Periodically, visits located within the Lake Superior Basin indicate varying degrees of operational deficiencies and plant malfunctions.

There are a number of Federal campgrounds, lifeboat stations, ranger stations, etc., which discharge to ground waters in the watershed. These are not included in this report.

I will not cover any of the material in Chapter IV, the Lake Superior Basin Description and Water Uses.

Going, then, to Chapter V on Page 35, Water Quality Monitoring and Special Studies

W. G. Turney

Part 1, Bacteriological Monitoring of Waters Along Lake Superior Shoreline

The Michigan Water Resources Commission maintains an annual summer sampling program of Michigan's Great Lakes coastline surface waters. Samples collected along the Lake Superior coastline are analyzed for total coliforms by the multiple tube method and results are presented as most probable number (MPN) of total coliform present in the water sample. Bacteriological data presented in Appendix L were obtained in 1967 and 1968. Only the minimum, maximum, and geometric mean values for each sampling location are expressed in this table, however, results for all samples collected and referred to are on file in the Lansing office of the Water Resources Commission.

Of the 14 locations along Michigan's Lake Superior shoreline for which there are 1967 and 1968 data available only one had a geometric mean value for total coliform over 1,000 organisms per 100 ml. in 1968, while in 1967 there were no such locations.

Chapter V, Part 2, Tributary and Lake Superior Monitoring Programs

Water quality monitoring of Great Lakes tributary streams was initiated by the Water Resources Commission in May 1955 to obtain background radioactivity information. The monitoring program has since been expanded to its present level of 41 stations located throughout the State, including a station in Lake Superior at Marquette. Results of sampling at this station from 1959 to 1968 are presented in Table 1 of Appendix M.

W. G. Turney

Beginning in 1963 the monitoring program was expanded to obtain a variety of background data on the quality of water flowing into the Great Lakes and connecting waters via the principal watersheds in Michigan's Lower Peninsula. Seven principal watersheds were sampled once in 1967 and three times in 1968. As of this year, 1969, five Lake Superior tributaries are being sampled monthly. These five tributaries are the Montreal, Presque Isle, Ontonagon, Sturgeon, and Tahquamenon rivers.

The specific objectives of the program are to determine long-term trends in the chemical, physical, and bacteriological characteristics of tributary streams to the Great Lakes in Michigan. The monitoring stations are located as close as possible to the mouths of the drainage basins and below all known sources of waste.

In addition to the regular monitoring of Lake Superior tributaries, the Commission staff has inaugurated a program of sampling of raw water from the Great Lakes. This is done at 10 water treatment plants along the shoreline of Lake Superior. The intent of the program is to establish existing water quality at the various intakes and indicate any trends which occur in the quality. These samples are currently collected annually. The first series was collected in 1967 and these results, along with the 1968 results, are shown in Tables 1 and 2 of Appendix O. Sampling locations are presented on Map 1.

In addition to the program conducted by the Water Resources Commission, the Michigan Department of Public Health requires that each water treatment plant submit monthly operating reports which contain results of physical, chemical, and bacteriological tests which are made on the raw water supply. The two programs supplement each other and furnish fairly complete documentation of the water quality at water intakes in Lake Superior.

The staff of the Water Resources Commission conducts various surveys throughout the State in accordance with its program of pollution prevention and abatement. One such program is a yearly surveillance of Michigan's interstate rivers. This program was initiated in 1967 with a series of 89 stations located throughout the State. Samples were collected at approximately 4-hour intervals for a 24-hour period at each station. Six of these stations are located on the Montreal River, and the 1967 results of this program are presented in Appendix P.

Chapter V, Part 3, Water Quality Survey of Lake Superior in the Marquette Vicinity, August 8-11, 1968

On August 8-11, 1968, a water quality survey was conducted to determine the effects of various wastewater discharges on the biota of Lake Superior and its major tributaries in the Marquette vicinity.

The water quality of Presque Isle and Marquette harbors was slightly impaired in small, scattered, localized areas. The overall water quality of Lake Superior in this vicinity was not adversely affected by natural or artificial sources. (The complete survey is contained in Appendix Q). This report covered both the intrastate and interstate waters of the Marquette area.

Go to Page 40, Chapter V, Part 4, Biological Survey of the Ontonagon River and Lake Superior, in the Vicinity of Ontonagon, Michigan, August 15, 1968

W. G. Turney

On August 15, 1968, a biological survey was conducted on the Ontonagon River and Lake Superior in the vicinity of Ontonagon, Michigan. The two major sources of waste discharge to these waters were the Hoerner-Waldorf Corporation paper mill and the Ontonagon Wastewater Treatment Plant.

Chapter V, Part 5, Biological Reconnaissance Survey of the Freda Copper Mill Discharge to Lake Superior in the Vicinity of Freda, Michigan, August 24 and 27, 1966

On August 24 and 27, 1966, a biological survey was conducted on Lake Superior in the vicinity of the Freda Copper Mill tailings discharge at Freda, Michigan. An effort was made to determine the effects of this stamp sand discharge upon the benthic fauna and to determine the extent of discoloration of Lake Superior waters by these wastes.

Benthic animal samples collected in the Freda-Redridge vicinity of Lake Superior failed to reveal any useful information concerning the effects of this discharge on the aquatic environment. The shifting sand bottom provided a very poor benthic habitat and a single midge larva was the only benthic animal found in the survey. Plankton samples collected during this survey showed that there were no discernible differences in the various plankton communities sampled.

Operations at this mill were permanently discontinued in December 1966. The company has no plans for reactivating this mill. (Complete survey is contained in Appendix S).

W. G. Turney

Chapter V, Part 6, A Biological Survey of South Bay, Lake Superior and observations on the Anna River, Munising, Alger County, Michigan, August 6, 1968

In 1957 a biological survey established that the benthic area of South Bay, Lake Superior in close proximity to Munising was biologically depressed. On August 6, 1968, a biological survey was conducted on South Bay and its major tributary, the Anna River, to determine present water quality conditions and detect any changes in the benthic macrofaunal community that may have occurred since the 1957 survey.

The major sources of wastewater discharges to South Bay are: The Kimberly-Clark Corporation paper mill discharging directly to South Bay; the Munising Wastewater Treatment Plant discharging to the Anna River; and a small community domestic sewage septic tank discharging directly to South Bay.

It appears that the principal source of degradation of South Bay, Lake Superior, arises from previously deposited woody materials which are still exerting a considerable influence upon the benthic ecology. This is substantiated by data showing almost no change in the benthic community between 1957 and 1968, even though marked improvements were made in paper mill waste control and municipal sewage treatment during that period. (Complete survey is contained in Appendix T).

This completes my summary of Michigan's technical report.

I would be happy to answer any questions that the conferees may have at this time.

MR. PURDY: Mr. Chairman, are there any questions?

MR. DOMINICK: Mr. Frangos?

Mr. Badalich?

Mr. Stein?

(No response.)

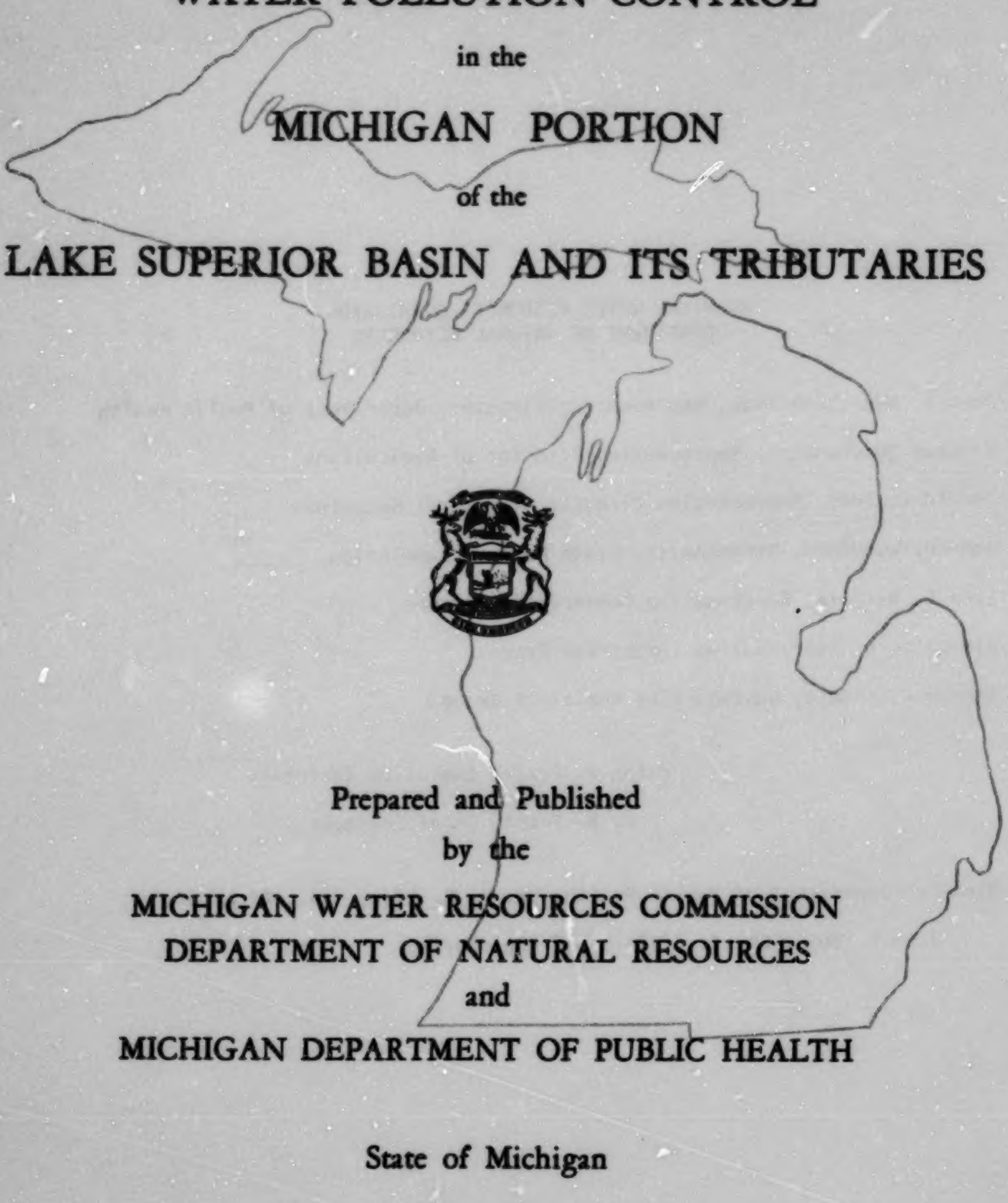
MR. PURDY: There are no questions.

We ask that the report in its entirety be placed in the record.

MR. DOMINICK: Very well.

(The Report on Water Pollution Control in the Michigan Portion of the Lake Superior Basin and Its Tributaries follows.)

REPORT
on
WATER POLLUTION CONTROL
in the
MICHIGAN PORTION
of the
LAKE SUPERIOR BASIN AND ITS TRIBUTARIES



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May 1, 1969

MICHIGAN WATER RESOURCES COMMISSION
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Report
on
Water Pollution Control
in the
Michigan Portion
# of the
Lake Superior Basin and Its Tributaries

Prepared for Presentation on Behalf of the
Michigan Water Resources Commission
of the
Department of Natural Resources
and
Michigan Department of Public Health
at the
Conference Called by the
Secretary of the Interior
on
Pollution of the Waters of Lake Superior
and
Its Tributary Basin
(Michigan, Minnesota, Wisconsin)

May 1, 1969

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Preface

This report contains information on the municipal and industrial waste disposal situation in the Michigan portion of the interstate waters of Lake Superior and in the tributaries to Lake Superior in Michigan. It delineates the statutes that provide the local units of government authority to build, own and operate waste treatment facilities. It delineates the State statutes for control of water pollution. It delineates the accomplishments that have been made in controlling pollution and the measures that are being taken to provide improved control. It also describes the uses being made of these waters and water quality conditions.

The report was prepared for presentation to the conferees at the Federal conference called by the Secretary of the Interior for their consideration and appraisal in (1) arriving at conclusions as to whether waste discharges originating from Michigan sources are endangering the health or welfare of persons in a state other than that in which the discharge or discharges originate, (2) determing the adequacy of measures that have been taken for abatement of pollution, and (3) determining the nature of delays, if any, being encountered in abating pollution.

The area encompassed by the report includes all of the Michigan portion of Lake Superior and its tributaries.

All sources of municipal sewage and industrial waste discharges to surface waters are covered. The nature of waste treatment or control measures in effect are described and the state agency action to control pollution and evaluate accomplishments is related.

The files and records of the Michigan Water Resources Commission and Michigan Department of Public Health are the sources of information contained in the report. The employed staffs of both agencies collaborated in assembling the material and preparing the report.

CHAPTER I

STATUTORY AUTHORITY

MICHIGAN LAW RELATING TO WATER POLLUTION CONTROL

A. Authority for local units of government to build, own, and operate waste treatment facilities:

1. Act 107, Public Acts of 1941 - An act to authorize township water supply and sewage disposal systems, and the issuance of revenue bonds or notes therefor.
2. Act 116, Public Acts of 1923 - An act to authorize townships to establish and maintain garbage systems or plants for the collection and disposal of garbage or contracting therefor, constructing or acquiring and maintaining sanitary sewers and sewage disposal plants; to provide for making, levying and collecting of special assessment bonds.
3. Act 342, Public Acts of 1939 - An act to authorize counties to establish and provide connecting water, sewer and/or sewage disposal improvements and services within or between cities, villages, townships and township improvement districts including disposal facilities and services and to provide methods for obtaining money for the aforesaid purposes.
4. Act 3, Public Acts of 1895 - An act to provide for the incorporation of villages and to define their powers and duties.
5. Act 215, Public Acts of 1895 - An act to provide for the incorporation of cities of the fourth class and to define the powers and duties of such cities.
6. Act 279, Public Acts of 1909 - An act to provide for the incorporation of cities and for revising and amending their charters.
7. Act 312, Public Acts of 1929 - An act to provide for the incorporation by any two or more cities, villages or townships, or any combination or parts of same for supplying sewage disposal.
8. Act 245, Public Acts of 1947 - An act to regulate the ownership, extension, improvement and operation of public water and sewage disposal systems lying within two or more public corporations; and to provide for the payment and security of revenue bonds issued for the construction, acquisition, extension and improvement of such systems.

9. Act 82, Public Acts of 1955 - An act to provide for the acquirement by a city of the water supply system and/or sewage disposal system of a metropolitan district and to permit such a city to own, maintain, operate, improve, enlarge and extend such systems either within or without its limits.

10. Act 76, Public Acts of 1965 - An act to authorize counties, townships, villages, cities and any other governmental unit to construct waste disposal systems by agreements or contracts with governmental units or agencies of another state.

11. Act 185, Public Acts of 1957 - An act to authorize the establishment of a department and board of public works in counties; to authorize the issuance and payment of bonds; and to prescribe a procedure for special assessments and condemnation.

12. Act 233, Public Acts of 1955 - An act to provide for the incorporation of certain municipal authorities to acquire, own, extend, improve and operate sewage disposal systems and to provide for the issuance of bonds to acquire, construct, extend or improve sewage disposal systems.

13. Act 320, Public Acts of 1927 - An act to authorize legislative bodies of municipalities to issue and sell bonds necessary for the construction of sewage disposal plants whenever a court of competent jurisdiction shall have ordered same.

14. Act 373, Public Acts of 1925 - An act to authorize legislative bodies of municipalities to issue and sell bonds necessary for the construction of storm and sanitary sewers whenever a court of competent jurisdiction shall have ordered same.

15. Act 94, Public Acts of 1933 - An act to authorize public corporations to purchase, acquire, construct, improve, enlarge, extend or repair public improvements within or without their corporate limits, and to own, operate and maintain the same; to provide for the issuance of bonds and refunding bonds payable solely from the revenues of public improvements; to provide for the imposition of special assessments against properties benefited by such public improvements, and for the issuing of special assessment bonds for the purpose of refunding outstanding revenue bonds.

16. Act 278, Public Acts of 1909 - An act to provide for the incorporation of villages and for changing their boundaries; to provide for acquiring by purchase, land without its corporate limits necessary for the disposal of sewage and garbage. . .

17. Act 188, Public Acts of 1954 - An act to provide for the making of certain public improvements by townships; to provide for assessing the whole or a part of the cost thereof against property benefited; and to provide for the issuance of bonds in anticipation of the collection of such special assessments, and for the obligation of the township thereon.

    Improvements which can be made under this act include construction and maintenance of sewers.

18. Act 359, Public Acts of 1947 - An act to authorize the incorporation of charter townships; to provide a municipal charter therefor; and to prescribe the powers and functions thereof including the installation of garbage disposal systems, the laying of storm and sanitary sewers and the installation of water systems.

19. Act 202, Public Acts of 1943 - An act relative to the borrowing of money by municipalities, and the issuance of bonds, notes and certificates of indebtedness; to provide for tax levies and sinking funds; to create the municipal finance commission; and to prescribe its powers and duties.

B. Authority for the control of water pollution:

1. Act 28, Public Acts of 1955 - Great Lakes Basin Compact. An act providing for cooperation of agencies of the state with the great lakes commission.

2. Act 243, Public Acts of 1959 - An act to regulate trailer coach parks; to prescribe the powers and duties of the director of the department of public health; and to provide remedies and penalties for violations.

3. Act 40, Public Acts of 1956 - An act to codify the laws relating to drains, and such structures and mechanical devices as will properly purify the flow of such drains; and to provide for the assessment and collection of taxes.

4. Act 20, Public Acts of 1964 - An act to regulate the impoundment and utilization of surplus water and to prescribe certain powers and duties of the water resources commission.

5. Act 291, Public Acts of 1965 - An act to protect riparian rights and of the public trust in navigable inland lakes and streams; to regulate the uses thereof including dredging and placing spoil on bottom lands; and to prescribe the duties and powers of the department of conservation.

6. Act 17, Public Acts of 1921 - An act to provide for the protection and conservation of the natural resources of the state and to create a department of conservation.

7. Act 247, Public Acts of 1955 - An act to authorize the department of conservation to regulate the filling in of submerged patented lands.

8. Act 209, Public Acts of 1968 - An act requiring certification of the supervisors of industrial and commercial waste treatment facilities and providing for a measure of control of operation of these facilities by the water resources commission.

9. Act 245, Public Acts of 1929 - An act to create a water resources commission to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the great lakes, with power to make rules and regulations governing the same and to provide penalties for the violation of the act.

10. Act 222, Public Acts of 1949 - An act to authorize public corporations to accept grants and other aid from the U.S. Government and from industries for the construction of pollution abatement facilities; and to authorize public corporations to enter into contracts with industries for the use of disposal facilities.

11. Act 329, Public Acts of 1966 - An act to provide state grants for sewage treatment facilites and to provide for administration of the grants by the water resources commission.

12. Act 75, Public Acts of 1968 - An act to allow state grants for municipal sewage treatment works on a matching basis with the federal grant anc to require that local agencies shall not receive a state grant until a comprehensive pollution control plan is approved by the water resources commission.

13. Act 76, Public Acts of 1968 - An act to authorize the issuance of general obligation bonds of the state of Michigan for the making of grants to municipalities of the state to be used in the construction and reconstruction of sewage treatment facilities; and to provide for the submission of the question of the issuance of said bonds to the electors of Michigan.

14. Act 211, Public Acts of 1956 - An act to prescribe certain powers and duties of the water resources commission in making studies and investigations in the establishment of sewage disposal districts.

15. Act 253, Public Acts of 1964 - An act to enable local units of government to cooperate in planning and carrying out a coordinated water management program in a watershed, and to prescribe certain powers and duties of the water resources commission.

16. Act 222, Public Acts of 1966 - An act to provide for the exemption of industrial water pollution control facilities from certain taxes.

17. Act 98, Public Acts of 1913 - An act providing for the supervision and control by the director of the department of public health over sewerage systems, and providing penalties for violations.

18. Act 87, Public Acts of 1965 - An act to license and regulate garbage and refuse disposal and to provide penalties for violation.

19. Act 196, Public Acts of 1963 - An act to control and prohibit the littering of public and private property and waters.

20. Act 288, Public Acts of 1967 - An act to regulate the subdivision of land; and to promote the public health by providing authority to the department of public health to approve subdivisions not served by public sewers on basis of suitability of soils.

21. Act 167, Public Acts of 1968 - An act to regulate and control the obstruction of the stream beds and channels, and flood plains of the waters of the state.

22. Act 218, Public Acts of 1967 - An act to protect the public health by providing for the supervision and control of bathing beaches open to the public; and to prescribe the functions of health agencies.

23. Act 61, Public Acts of 1939 - An act to provide for a supervisor of wells; to provide for the prevention of waste and for the control over certain matters, persons and things relating to the conservation of oil and gas and for the making and promulgation of rules, regulations and orders relative therefor; to provide for the plugging of wells and for the entry on private property for that purpose; to provide for the enforcement of such rules, regulations and orders and of the provisions of this act and to provide penalties for the violations thereof; to prevent damage to or destruction of fresh water supplies and valuable brines by oil, gas, or other wastes; to require the disposal of salt water and brines and oily wastes produced incidental to oil and gas operations, in such a manner and by such methods and means that no unnecessary damage or danger to or destruction of surface or underground resources shall result.

24. Act 306, Public Acts of 1927 - An act to provide for county and district health departments; to prescribe their powers and duties; to provide for the apportioning of funds appropriated by the state, for aid to city, county and district health departments.

25. Act 350, Public Acts of 1865 - An act to protect fish and to preserve the fisheries by preventing the unlawful dumping into the waters of certain materials.

MICHIGAN'S CLEAN WATER BOND PROGRAM

In November 1968 Michigan electors, by a three to one margin, authorized the sale of $335 million worth of bonds for purposes of assisting communities in improving existing and constructing new waste treatment plants; $50 million of this total bond program is to be used for sewer construction assistance for communities without sewers which are contributing to an existing pollution problem and have low property valuation.

Implementing legislation is now being developed by the legislature and proposed bills have been introduced. One would amend Act 329, Public Acts of 1966 to provide a state grant of 25 percent of the cost of construction of treatment works eligible for Federal participation under Public Law 84-660 and to advance one-half of the Federal grant if Federal funds are not available. A second bill provides state grants to assist local agencies in the construction of collecting sewers. This grant would be for 50 percent of the cost of construction of collecting sewers in excess of 10 percent of the state equalized value of all taxable property within the political boundaries of the unit served.

ABSTRACT OF THE ATTORNEY GENERAL'S OPINION NO. 4590 ON AUTHORITY OF WATER RESOURCES COMMISSION TO REGULATE COPPER AND IRON MINING OPERATIONS

1. Art. 4, Sec. 52, Constitution of 1963, declares State's public policy is that the air, water and other natural resources of the State are to be protected from pollution, impairment and destruction and to this extent it prohibits the legislature from enacting any law which would violate the constitutionally declared public policy.
2. Statutes governing Water Resources Commission are not to be construed to permit destructive pollution of streams in the State.
3. Copper and iron mining operations are subject to the protective provisions of the water resources act.
4. Water Resources Commission is not authorized to issue order allowing destruction of fish and game habitat.

CHAPTER II

STATE OF MICHIGAN POLLUTION CONTROL PROGRAM

Administration of water pollution control functions in Michigan necessarily follows the division of statutory responsibility set forth in the previously cited statutes subject to correlation, wherever possible, of member department interests and objectives with those of the Water Resources Commission. The Water Resources Commission and the Department of Public Health and their respective staffs carry the principal burden of water pollution control in Michigan at the state level.

WATER RESOURCES COMMISSION POLLUTION CONTROL PROGRAM

Goal

The objective of the Michigan Water Resources Commission is to bring all existing unlawful pollution under continuing effective control and prevent the development of unlawful pollution from new sources, population growths, or increased industrial expansion and, where such incidents occur, limit their duration and intensity to the fullest extent consistent with requirements of the Water Resources Commission statute. Under the Michigan statute (Appendix A), it is unlawful for any person directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety or welfare; or which is or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters, or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life or plants, or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired. The discharge of any raw sewage of human origin, directly or indirectly into any waters of the state is prima facie evidence of a violation of the statute unless such discharge is permitted by an Order, rule, or regulation of the Water Resources Commission.

Action Regarding Inadequacies

Where inadequacies in control of waste discharges are determined to exist, an opportunity is provided for establishment of voluntary corrective action. When it appears to the Michigan Water Resources Commission that a voluntary program will not be successful or may not be accomplished within a reasonable time period, statutory procedures are initiated. Orders adopted contain specific effluent restrictions and specific dates for approval of construction plans and specifications, awarding of construction contracts and commencement of construction, and the completion of construction and attainment of pollution abatement as required by the Order.

Combined Sewerage Systems

New sewerage systems must be developed on the basis of separate sewers for storm water and sanitary waste water. When at all feasible, separated sanitary wastewater systems shall not be discharged into combined systems. If such discharge does occur control facilities must be developed on the combined system so as to protect present and future water uses of the receiving waters consistent with the requirements of the Water Resources Commission statute. Problems associated with the overflow of storm and sanitary waste from existing combined public waters must be corrected on or before June 1, 1977.

Nutrients in Municipal and Industrial Waste Discharges

Nutrient discharges, particularly with respect to phosphates, to public waters must be controlled. Persons proposing to make a new or increased use of waters of the state for waste disposal purposes are required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and as a long-term objective, all existing waste dischargers will be required to provide facilities for the removal of phosphorus compounds by June 1, 1977. See page 17 for further discussion.

Watercraft Pollution Control

The discharge of sanitary waste from recreational watercraft will be controlled by rules and regulations adopted by the Water Resources Commission on February 22, 1968, with an effective date of January 1, 1970 (Apendix B).

Control of New Waste Discharges

The Michigan Water Resources Commission will prevent the development of new problems by continued implementation of Section 8 (b) of its statute which requires the filing of a statement of use by any person proposing to make a new or substantial increase in use of waters of the state for waste disposal purposes. The Commission, upon receipt of a statement, makes an Order stating such minimum restrictions as may be necessary to guard adequately against unlawful uses of waters of the state.

Water Quality Standards

Water quality standards and use designations for all inter- (Appendix C) and intrastate (Appendix D) waters have been adopted. Water use designations, together with a plan of implementation and enforcement of the standards were adopted for interstate waters on June 28, 1967, while the intrastate water standards were adopted on January 4, 1968. The use designations for intrastate waters were established on March 20, 1969. A series of five water and related land resource inventory reports were compiled by the staff of the Water Resources Commission and were used, along with other supporting data, as background material for determining use designations.

Certain intrastate waters are not at present designated for specific uses. The Water Resources Commission did not designate uses for waters receiving discharges from the copper and iron mining industries pending an Attorney General's opinion as to the authority of the Commission to regulate mining wastes. This opinion has now been received and, consistent with the Commission rules, a public hearing is scheduled in August 1969 at Escanaba, at which time use designations will be considered for these waters. Adoption of use designations by the Commission is expected within 60 to 90 days following the hearing.

On interstate waters, where noncompliance with the standards is determined to exist as the result of a discharge from an existing municipal wastewater treatment plant, treatment facilities adequate for meeting established water quality standards must be provided no later than June 1, 1972. Secondary treatment is required as a minimum unless it can be demonstrated that a lesser degree of treatment or control will provide for water quality enhancement commensurate with present and future water uses. Exception to the requirement for at least secondary treatment must be justified to the satisfaction of the Michigan Water Resources Commission and the Federal Water Pollution Control Administration. Presently identified existing discharges of raw sewage of human origin to public waters must be corrected by June 1, 1972. Year-round disinfection of all final effluents from municipal sewage treatment plants is required. Industrial waste discharges must meet the same treatment requirements as municipal waste effluents and industrial waste problems identified in the interstate plan reports must, no later than June 1, 1970, have adequate treatment or control facilities.

Inspection and Facility Approval

The Water Resources Commission staff inspects each incipient pollution problem regularly. All Orders now adopted by the Commission to both industries and municipalities, require routine analysis and reporting of the quality of wastes discharged to public waters. In addition, surface water quality and waste effluents are monitored so as to identify the need for corrective action to abate existing problems and whenever possible so as to detect and identify the approach of pollutional conditions in time to initiate appropriate corrective action prior to the development of a statutory injury. The Water Resources Commission staff reviews and approves or rejects plans for industrial waste treatment or control facilities and counsels with management on industrial waste treatment or disposal problems. It develops appropriate restrictions and time schedules for Commission approval to correct or prevent pollution problems, and participates in enforcement procedures initiated by the Commission through statutory hearings and enforcement of Commission Orders in court when voluntary compliance is not forthcoming.

Mandatory Certification of Industrial Treatment Plant Operators

Act 209, Public Acts of 1968, requires that all industrial or commercial establishments discharging liquid wastes into the waters of the state shall have waste treatment facilities under the specific supervision of persons who have been certified by the Water Resources Commission as properly qualified to operate the facilities. It further requires that monthly operating reports shall be filed with the Commission showing the effectiveness of the treatment facility operation and the quantity of the wastes discharged. Implementation of this program is now under formulation by the Commission with assistance by an industrial management advisory committee.

Data Processing

The Michigan Water Resources Commission is now developing data storage and retrieval systems. Full consideration is being given to the systems now employed by the Ontario Water Resources Commission and the United States Government so as to afford easy exchange of data and cooperative use of the three systems. Reporting forms are in the final stages of preparation and the entire system will hopefully be operational in about three years.

DEPARTMENT OF PUBLIC HEALTH POLLUTION CONTROL PROGRAM

The Department of Public Health, acting through its Division of Engineering, exercises supervisory control over all public sewerage systems. The Director of the Department is required by statute, Act 98, Public Acts of 1913, as amended, to "exercise due care to see that all sewerage systems are properly planned, constructed and operated so as to prevent unlawful pollution of the streams, lakes, and other water resources of the state". The companion statute, Act 245, Public Acts of 1929, as amended, defines unlawful pollution and authorizes the Water Resources Commission to "establish such pollution standards for lakes, rivers, streams, and other waters of the state in relation to the public use to which they are or may be put, as it shall deem necessary". Such pollution standards and the water quality criteria relating to the public uses, recently approved for both interstate and intrastate streams, provide the framework upon which decisions are made and actions taken in relation to the planning, design, construction and operation of all sewer systems and treatment works. Elements of this supervisory program include the following:

Facilities Planning and Approval

1. Review engineering reports establishing the basis of design for projects involving collection and treatment of wastewater and consult with the engineers and municipal officials on elements of the proposed design prior to development of plans and specifications for the project, require modification of proposed design where appropriate and, when found to be satisfactory, approve same.

2. Review, approve or reject and secure changes in plans and specifications submitted for new municipal systems or for changes in existing systems, both for collection and treatment. No public sewerage system may be built or altered without specific approval by construction permit.

3. Conducts inspections to determine that construction of public sewerage systems conforms to approved plans and specifications.

4. Require reduction of overflows from existing combined sewer systems. Adoption of accelerated programs for effective control of overflows from such systems is strongly urged. Progress has been made in several communities such as Houghton, Munising, and Marquette.

5. Require municipal rather than private ownership of all sewerage systems serving the public in the belief that more dependable and effective operation and overall pollution control is thereby assured.

6. Counsels with officials of municipalities and their consulting engineering agents as to the need and methods for collection and treatment of wastewater.

7. Strongly encourage and, where appropriate, require the development of multicommunity area planning to provide effective services and pollution control facilities utilizing sound management principles. Many such areas are currently served by an integrated system of sewers, interceptors, and treatment works. Others are being so planned in several areas. Examples are Houghton, Hancock, and Marquette.

8. Encourage the admission of industrial wastes in municipal sewerage systems where such wastes will not adversely affect the system and its performance in relation to effective pollution control.

9. Foster, encourage and assist communities in the adoption of effective and practical sewer use ordinances for the control of industrial wastes to be admitted to the sewerage system. In many instances, technical assistance and counsel is provided in the location, analyses, evaluation, and pretreatment of wastes, particularly those detrimental to biological treatment processes and in the development of effective corrective measures and controls. Examples are paper board and paint wastes at L'Anse and mineral research wastes at Houghton.

10. Encourage, and where appropriate, require communities to conduct studies, pilot or plant scale, to provide a dependable basis of design for unusual combinations of industrial and municipal wastes to be treated where sufficient information is not available for design purposes.

11. Encourage and assist communities to conduct studies to establish effective methods for removal of phosphates from their wastes at existing treatment works. In the last year, several communities have purchased spectronic equipment and are obtaining background data on phosphates in their wastes. Some are doing bench scale tests on phosphate removal with iron and aluminum salts. These plants include Ironwood, Ontonagon, Houghton-Hancock, and Marquette.

12. Require facilities for removal of phosphates in the design of new treatment works, consistent with the adopted policy of the Water Resources Commission.

13. Require expansion and improvements of municipal facilities, both for collection and treatment as present capacity is approached, rather than wait until the facilities are overloaded before taking action. Approval of sewer extensions is withheld where additional loadings would exceed the capacity of the system until an acceptable program for relief is officially adopted. "Sewer bans" have been imposed in such circumstances, such as at Laurium. Authority for such action has been tested and upheld in the courts.

14. Order changes in facilities or their operation when requirements of the statutes have not been met. Alternatively, cases involving deficiency in facilities are referred to the Water Resources Commission for action.

15. As agent for the Water Resources Commission, review, approve or reject plans submitted for new sewer systems, other than municipal, or for changes in existing ones.

16. Assist and encourage local health departments to effectively direct and control the installation of private sewage disposal systems where public sewer systems are not available for connection.

17. Require construction of separate sanitary sewers for new community systems.

Facility Operation - Supervision, Visitation

1. Require the effective operation of all treatment works, including pumping stations and sewer system appurtenances.

2. Require all municipalities to submit reports monthly on the operation of treatment works. Standard report forms are provided by the Department and each municipality is advised as to the minimum information to be reported and the frequency (number of days per week) of reporting. Included are both physical data and laboratory analyses to establish loadings on the plant, performance of plant units, and the volume and characteristics of the plant effluent. Report forms are presently being revised to include chemical analyses, including phosphorus data (Appendix E). Such information is used to determine effectiveness of overall plant performance, deficiencies of component facilities, capacity reserves for additional loadings, and operational problems and shortcomings. Action is taken to assist in corrective measures and to require correction.

3. Supervise operation by on-site inspection, instruction and consultation with plant operating personnel. Adequate services of this nature requires visitation once during each three months on the average.

Privately-Owned Public Sewerage System Policy

1. Require private developers of public sewerage facilities to obtain authorization and approval from the township board as to all related matters as required by the constitution, applicable laws, and local ordinance.

2. Require a plan for the effective and continuous operation of the facilities by the owner.

3. Require a resolution by the township board that it will assume complete responsibility for the effective operation and maintenance and make any necessary repairs, replacements, extensions or improvements to the facilities which are required in the public interest if the private owner should fail to do so. (Complete text of the policy is in Appendix F).

Operator Certification and Training

1. Require all municipalities to employ operators whose competency has been certified by the Department. By statute, it is mandatory that the person in charge of the plant be so certified. Over 600 operators have been so certified on the basis of education, experience, and written examinations. About 200 operators with plant experience are examined each year. A high percentage of applicants are certified operators seeking to establish qualifications for a higher plant classification.

2. Conduct formal group training sessions to impart specific information related to effective operational control, to provide opportunity for exchange of information and experience and to provide incentives for self-study and development. Over 325 operators attend a 2-day meeting each year conducted by Department engineers and chemists. A series of four 5-day sessions in laboratory procedures involving chemical and bacteriological analyses have been conducted concurrently with four 5-day sessions in colorimetry by the Department staff during January and February the past two years; 225 operators who presently perform such tests at their plants registered for these short courses. Evening courses are held throughout the state for a 12-week period in mathematics, chemistry or hydraulics as applied to wastewater works operation, in a cooperative program with other agencies and organizations. Special courses in process control, safety, and related areas are sponsored with other groups.

3. Encourage operators to meet on a regular schedule, usually about once monthly, on their own initiative to exchange information on plant operational problems and experiences and to invite speakers to discuss selected subjects related to facilities design and maintenance, laboratory equipment, etc. About ten such groups meet regularly with about 200 operators participating. One such group is the Upper Peninsula Section of MWPCA.

Disinfection Policy and Practice

1. Require all municipalities to disinfect the plant effluent before discharge to the surface waters of the state. This policy was adopted in January 1967 (Appendix G). Virtually all communities in the state are conforming to this policy.

2. Require the provision of adequate facilities and their operation, monitoring, and testing in such a manner as to assure continuous effective disinfection.

3. Require regular reporting on forms furnished by the Department of chlorine used daily, results of chlorine residual readings, and related information. Most communities are performing bacteriological analyses on the chlorinated effluent as a check on the chlorine dosage and chlorine residual regimens. (Appendix H, Table 1). Other small communities are currently planning to apply additional refinements in control this year.

STUDIES ON REMOVAL OF PHOSPHORUS FROM WASTEWATER AT MUNICIPAL TREATMENT PLANTS

During the past two years studies have been made by several Michigan municipalities on removal of phosphorus from the wastewater collected in their community sewer systems. Two general methods were utilized: One involving the addition of metal salts either to the raw sewage or activated sludge with or without the addition of polymers; the other involving management of the activated sludge process without chemical additions. The central objectives of these studies were:

1. To determine phosphorus concentrations and loadings at several municipal treatment plants.

2. To determine the amenability of wastes at various locations to phosphorus removal by one or more methods in relation to primary sedimentation, trickling filters and activated sludge.

3. To explore the effect of chemical additions for phosphorus removal on the removal of BOD and suspended matter at primary, trickling filter and activated sludge installations.

4. To study the degree of compatibility of metal salts with biological and chemical (polymer) treatment systems, when added for phosphorus removal.

5. To furnish information upon which design of facilities for phosphorus removal may reasonably be predicated.

A variety of study methods and procedures were followed. Some involved bench studies only, using jar tests on the wastes undergoing treatment at the plant; others included full-scale plant operation applying the knowledge acquired in the bench work; and others were conducted at pilot plants built to establish a basis of design for facilities to be added.

The first of these studies was conducted at Grayling, a resort community of less than 2,000 resident population. Bench studies indicated that 90 percent or more of total phosphorus could be removed from the raw wastes by plain sedimentation with the addition of 15-30 mg/l of ferrous chloride as iron, 30-50 mg/l of sodium hydroxide as equivalent calcium carbonate and about 0.5 mg/l of an anionic polymer. It was indicated that the caustic could be added a few seconds following quick mix of the iron salt with the raw sewage and that a selected polymer, if added following an interval of about five mintues, would form a good floc after a short period of slow flocculation and would effectively remove the phosphorus. A very low order of removal of total phosphorus was experienced when no polymer was added. These principles were applied to full-plant scale operation within the limitations of the facilities. The iron and caustic were added to the sewage at the lift station with no formal mixing facilities and the polymer was added at the entrance to the settling tank with crude and temporarily rigged mixing equipment. During the period of plant scale application the plant was grossly overloaded hydraulically by reason of seasonal influx of tourists and National Guard encampment. In spite of these adverse circumstances total phosphorus removal ranged between 60 percent and 80 percent with a most probable mean value of 72 percent. Correspondingly, suspended solids removal ranged from 60 percent to 87 percent with a mean value of 78 percent representing an increase of about 27 percent compared with performance when chemicals were not added. Removal of five-day BOD increased from a mean value of about 40 percent before and after the study to about 58 percent during the study. It should be noted here that the raw sludge was hauled to a land disposal site.

Work of a similar nature, both in bench studies with jar tests and full-scale plant operation, was performed at the Village of Lake Odessa. Here the municipal treatment facilities include trickling filters and sludge digestion facilities. The same chemicals were applied to the raw sewage as at Grayling in about the same concentration except that the dosage rates of the ferrous chloride were less effectively controlled, resulting in rather widely fluctuating dosage rates, ranging from daily averages of about 15 mg/l to 60 mg/l. No mixing or flocculation equipment was installed. Wastes varied widely from day to day and week to week in strenth and quantities by reason of changing admixtures of wastes from a food processing plant. Total period of the plant scale study both with and without chemical treatment was 87 days including 33 days when valid operating data were obtained under controlled chemical feeding conditions. These data generally confirmed Grayling observations although removal of total phosphorus, five-day BOD and suspended solids by primary sedimentation was somewhat lower. It was further indicated that:

1. Trickling filter performance is enhanced, as measured by five-day BOD and suspended solids removal, by this regime of chemical additions to the raw sewage. Most probable mean values for over-all plant suspended solids removal increased from about 78 percent without chemical additives to about 89 percent with chemicals. Correspondingly, BOD removal increased from about 60 percent to about 80 percent.

2. Over-all plant reduction of total phosphorus was quite stable with values generally between 75 percent and 92 percent removal and a mean value of 82 percent.

3. Total phosphorus in the digester supernatant were quite low with most values below 75 mg/l. This appears to confirm the findings of E.A. Thomas as reported in his published work conducted at the treatment plant for the community of Uster in Zurich, Switzerland.

Other work involving use of ferrous chloride and polymers was performed in 1967 at the Village of Whitehall and the City of Traverse City. The studies thus far have been bench scale, employing jar tests similar to those at Grayling and Lake Odessa. Results have generally confirmed the earlier findings at the other two plants. At Traverse City it is planned to explore further, by pilot plant studies, how to most effectively remove phosphorus from their peculiar wastes in a biological treatment process requiring a high order of removal of BOD and suspended matter. The municipal sewage includes substantial quantities of wastes from cherry processing operations.

Rather extensive studies of phosphorus removal by metallic ion precipitation in a biological system have been conducted since September 1967 at the municipal activated sludge plant of the City of Warren. A pilot plant was installed as the first step in a study to establish a basis of design for extending the present capabilities of the plant to meet an effluent requirement of 8 mg/l 20-day BOD and 80 percent removal of total phosphorus. Pilot plant components consist of activated sludge units followed by rapid sand filters. Ferrous chloride or aluminum sulfate were fed into the aeration tanks near their point of overflow at about 15 mg/l. No polymers were added. It has been demonstrated in daily operation and testing that:

1. Total phosphorus precipitated by metallic ions were removed by activated sludge in the order of 70 percent or higher consistently and an additional 10 percent or more was removed by the rapid sand filters.

2. The addition of iron or aluminum directly in the mixed liquor for phosphorus removal is compatible with the activated sludge process when operated for high degree BOD removal.

Other work of a pilot nature has been conducted by the cities of Detroit and Trenton for the past year and a half under demonstration grants from the Federal Water Pollution Control Administration. Both projects utilize activated sludge and Detroit also is investigating trickling filters. Data obtained will be used, hopefully, for the design of formal facilities to be added to the existing primary plants for improved treatment, including phosphorus removal. The pilot plants for activated sludge and trickling filters at Detroit have a combined nominal capacity well in excess of 100 gpm and are very flexible and adaptable to a wide variety of control patterns and methods. The pilot plant studies at the city of Trenton utilized two separate activated sludge plants. One was used essentially as a test control on the unit in which phosphorus removal was under study. Studies were made on removal of phosphorus in the activated sludge with addition of metal salts, and also by "acid stripping" of the activated sludge. While both apparently are successful, a decision as to which of these procedures will be used in the Trenton plant has not yet been announced.

At the Benton Harbor - St. Joseph activated sludge plant, a thirty day study on full plant operation indicated removal of about 90 percent total phosphorus using ferrous chloride and a polymer, both applied ahead of primary sedimentation.

Studies have been made at the Lansing activated sludge plant of the effect of varying concentrations of pickling liquors in the raw sewage on removal of phosphorus in the system. Similar studies are in progress at the Jackson activated sludge plant.

In addition to the specific installations which we have discussed here, there are many treatment plants in Michigan where tests have been performed to establish the level of phosphorus in the municipal wastes, their variations and some of their specific characterists. In some of these plants, jar tests have been made in the laboratory using chemical additives to determine amenability of the wastes and dosage rates required for phosphorus removal. In others, preliminary jar test studies have been made on activated sludge without chemical additives. These studies have demonstrated that methods are available, using conventional wastewater treatment facilities, with supplemental equipment for the removal of phosphorus from wastewater. It is also established that phosphorus concentrations in wastewaters vary quite widely from town to town.

It seems apparent that laboratory bench scale testing is essential to the establishment of a facility design. In many cases, pilot plant studies will be necessary. In all cases, flexibility must be designed into phosphorus removal systems to permit optimum control and achievement of results.

WATER RESOURCES COMMISSION'S POLICY ON PHOSPHATE REMOVAL

The Water Resources Commission's pollution control program concerning phosphate removal was established in October, 1967 when the following policy was adopted:

"WHEREAS, Nutrients released to our water environment are a contributing factor to an accelerated rate of aging of inland lakes and streams, including the Great Lakes, as evidenced by growths of aquatic weeds and algae; and

WHEREAS, phosphorus is an essential element to such growths;

THEREFORE BE IT RESOLVED, that persons proposing to make a new or increased use of waters of the state for waste disposal purposes will be required, coincident with the new or increased use, to utilize such technology and processes which are known for the removal of phosphorus compounds and that as a long-term objective, all existing waste dischargers will be required to provide facilities for the removal of phosphorus compounds by June 1, 1977".

The nutrient policy as applied to stabilization lagoons was adopted at the November-December meeting of the same year and reads as follows:

> "Generally, these requirements may be reasonably met by waste stabilization lagoons in small communities and others where the lagoons will provide equal or greater assurance of meeting established water quality objectives for the receiving waters (other than nutrients) than may be provided by other types of treatment facilities for such conditions.
>
> The waste stabilization lagoon process does not provide a high degree of removal of phosphates, therefore, such installations may not be adequate for discharge of the effluent at certain locations such as inland lakes and impoundments.
>
> When practical methods are developed for effective removal of phosphates in the lagoon process by modification of design features or by process control methods, owners of any such facilities will be required to incorporate and utilize such features and methods."

CONSTRUCTION GRANT PROGRAM

The Commission maintains a grant administrator whose responsibilities include assisting municipalities in all phases of the construction grant program. Prospective applicants are advised of state and federal grant programs currently in effect for sewage treatment works, where to obtain and file applications, and are kept advised of all program developments of importance. Under administrative rules of the Commission, grants are allocated by the administrator according to priority points assignment. The administrator also certifies projects to the State Treasurer, serves as intermediary between the city and the Federal Water Pollution Control Administration for federal grants and makes inspections of grant projects.

No financial assistance for maintenance of pollution control facilities is provided by the state. Technical assistance is provided by the Department of Public Health, Division of Engineering. Instruction in maintenance of specific pieces of treatment plant equipment is provided through the Department's operator training program.

The state also provides for the exemption of water pollution control facilities from certain taxes.

All applications for water pollution control tax certificates are filed with the State Tax Commission, but are referred to the Water Resources Commission for approval. If the Water Resources Commission finds that the facilitiy is designed and operated primarily for the control, capture and removal of industrial wastes from the waters, and is suitable, reasonably adequate and meets the intent and purposes of the Water Resources Commission statute, it so notifies the State Tax Commission who then issues the certificate.

A facility covered by a tax certificate is exempt from personal property taxes, and tangible personal property which becomes affixed and made a structural part of the real estate of such facility is exempt from sales and use taxes.

Provisions are made in the Act for modification or revocation of the certificate under certain conditions.

CHAPTER III

DISCHARGES TO SURFACE WATERS

Industries

The Water Resources Commission staff has under surveillance 21 industries which discharge wastewater to public waters in the Lake Superior Basin. The 21 industries that discharge waste effluents to surface waters are listed in Appendix I, together with their pollution status rating, type of treatment provided, waste effluent data where such is available and formal abatement action taken by the Commission. The pollution status ratings are updated annually and represent the Water Resources Commission's staff effort to fairly appraise each incipient pollution problem as indicated by a review of operating reports, observations, inspections or surveys during the preceding calendar year. The ratings are by letter code as follows:

A. Control adequate
B. Control provided - adequacy not established
C. No control - need not established
D. Control provided - protection unreliable
E. Control inadequate

Table 1 summarizes the pollution status ratings of the four industries which have effluent discharges directly to Lake Superior.

Table 1

Pollution Status Rating	Type of Industry			
	Chemical	Paper	Electric Power	Total
A			4*	4
B	1	1		2
C				
D				
E				
Total	1	1	4	6

* This figure represents two power companies, each with two ratings.
As shown by the table, all four industries have either an A or B rating.

TABLE 2

SUMMARY OF INDUSTRIAL SURFACE WATER DISCHARGES IN THE LAKE SUPERIOR BASIN

April 1, 1969

Pollution Status Rating April 1, 1969 / River Basin	Montreal	Black	Presque Isle	Mineral	Ontonagon	Sleeping	Portage	Sturgeon	Falls	Dead	Carp	Chocolay	Au Train	Two Hearted	Taquamenon	Waiska	Minor Drainage Areas	Total
A				1	1				3		3							8
B	2	1		1	1	1	3				1	1			1		4	16
C																		
D																		
E					1					2								3
Total	2	1		2	3	1	3		3	2	4	1			1		4	27

Note: Eighteen industries are reflected here; one industry has six ratings, one has three and two have two ratings. One industry also has a discharge to Lake Superior.

In addition to the four industries which have effluent discharges directly to Lake Superior, 18 have effluent discharges to inland surface waters tributary to Lake Superior (Marquette Board of Power and Light discharges to both Lake Superior and the Dead River). The pollution status ratings for these industries are summarized by tributary river basins in Table 2. As shown in the table, three have E ratings.

Governmental Units

The 41 governmental units that discharge waste effluents to public waters are listed in Table I Appendix J, together with the type of treatment provided, waste effluent data where such is available, abatement action taken and present status. The data was obtained from records of the Michigan Department of Public Health and the files of the Water Resources Commission. Nearly all of the waste effluent data reflect averages for the month of September, 1968. Only one municipality, Baraga, discharges wastewater directly into Lake Superior. The remaining 39 discharge to various tributaries inland from the lake.

The 41 municipalities in the basin had a 1964 estimated population of 98,945 people. Ten of these municipalities, with 40.4 percent of the total population, are serviced by secondary biological processes. Sixteen communities, with 10 percent of the total population, have partial collection systems but no treatment facilities. Of the 16, however, 13 have engineering studies underway to correct existing problems. Eight municipalities, representing 2.7 percent of the total popluation, are considered to be discharging improperly treated sewage to the waters of the state.

Interstate River Basins

The Michigan portion of the Lake Superior basin has only one interstate stream, the Montreal River. Industrial and municipal waste discharges within the Montreal watershed are listed below and in Appendices I and J.

Municipality	Industry
Erwin Twp.	Superior Packing Co.
Ironwood	William E. Maki Slaughterhouse
Ironwood Twp.	

The three municipalities had an estimated population of 10,780 people in 1964, all of which are served by secondary waste-treatment facilities. In keeping with the Michigan Department of Public Health policy on disinfection of sewage treatment plant effluents (Appendix G), Ironwood and Ironwood Twp. provide year around chlorination. Erwin Twp., however, being served by septic tanks and sand filters, does not disinfect their sewage effluent. Flow data and waste characteristics are not available for the two industries in the basin, however both are served by primary waste-treatment facilities.

Federal Installations

There are twelve Federal installations which discharge waste effluents into surface waters in the Michigan portion of the Lake Superior basin (see Appendix K). In keeping with Commission's requirements on phosphorus removal (see page 17) staff has recommended that facilities to meet this requirement be provided at the two major Air Force Bases (Kincheloe and Sawyer) in the basin. Four of the installations are light stations (one is a former light station) with raw or semi-treated sewage discharges directly into Lake Superior. The Michigan Water Resources Commission has recommended and is currently awaiting alleviation of these problems. Treatment is considered adequate at the other six Federal units in the basin.

There are a number of Federal campgrounds, lifeboat stations, ranger station, etc., which discharge to ground waters in the watershed; these are not included in this report.

CHAPTER IV

LAKE SUPERIOR BASIN DESCRIPTION AND WATER USES

BASIN DESCRIPTION

Introduction

Lake Superior is the largest of the Great Lakes and the second largest fresh water lake in the world. It has 31,820 square miles of surface area (16,231 square miles in Michigan), and is 350 miles long, 160 miles wide and 1,333 feet deep (maximum). The Lake has a total volume of approximately 3,000 cubic miles.

The surface of Lake Superior averages slightly over 600 feet above sea level--21.67 feet above Lake Huron into which it drains, and the deepest point is 733 feet below sea level. The land drainage area of Lake Superior is 48,200 square miles of which 16 percent (7,700 square miles) is in Michigan (the area above the locks at Sault Ste. Marie). Lake Superior discharges to the lower Great Lakes through the St. Marys River. The mean discharge from the lake since 1900 has been 73,400 cubic feet per second (cfs.).

Lake Superior lies almost wholly within the Precambrian Canadian shield and the northwestern shore of Michigan's Upper Peninsula is part of this shield. The Precambrian rocks were formed approximately half a billion years ago and contain essentially all the mineral wealth of the peninsula. This wealth includes iron and copper deposits as well as a limited number of precious minerals. The Cambrian epoch (185-500 million years ago) left its mark along the northcentral and northeastern shore of the Upper Peninsula as demonstrated by the sand stones of the Pictured Rocks and the ledge rock of Tahquamenon Falls. The existing Lake Superior basin is of relatively recent origin, the present water level having been reached only about 2,500 years ago.

Lake Superior is more irregular in outline than the other Great Lakes. With the exception of the eastern Upper Peninsula of Michigan, the lake is surrounded by an escarpment ranging from 400 to 800 feet high. In most areas the highland is either immediately adjacent to the shoreline or close to it.

Approximately 30 percent (913 miles) of the Lake Superior shoreline is within Michigan's boundaries. This 30 percent contains some of the Nation's most unique and scenic shoreline. The wide sand beaches of Whitefish Bay; the great perched dunes near Grand Marais; the sheer cliffs of the Pictured Rocks; the remote Huron Mountains and the many miles of primeval wilderness constitute a valuable recreational and aesthetic resource.

Lake Levels

The level of Lake Superior and the discharge of the St. Marys River are maintained by the portion of the precipitation that falls directly on the lake surface, drainage from the watershed, and very limited outseeping of groundwater. Evaporation from the lake surface is generally considered to be approximately equal to the precipitation upon it.

Precipitation on the lake and its drainage basin is well distributed throughout the year. A majority of the precipitation which falls during the winter months occurs as snow. For example, one hundred and fifteen inches of snow fell in Calumet, Michigan, in the month of January, 1950. In severe winters snow accumulation approaches four feet along the south shore of Lake Superior. The 67 year (1900-1967) average annual precipitation is 30.00 inches with extremes being a low of 22.81 inches in 1905 and a high of 38.25 inches in 1951.

In addition to precipitation and runoff, Lake Superior receives water by direct diversion via the Long Lake-Ogoki projects located along the north shore. This diversion averages nearly 5,000 cfs. of water which formerly flowed north to Hudson Bay. Because of the regulatory works at Sault St. Marie, this diversion has not affected the level of Lake Superior. Without the works, the level would have been raised one-quarter of a foot.

Since 1860, the level of Lake Superior has varied between a high monthly average elevation of 604.05 feet (August 1876) to a low of 599.88 feet (April 1926), a range of 4.17 feet. The lake level normally fluctuates about 1.2 feet per year with the low in March and the high in September.

Since 1922, the outflow from Lake Superior into the St. Marys River has been controlled by regulatory works above the rapids at Sault Ste. Marie. These works were built as a condition of an order of the International Joint Commission granting a permit to divert water around the rapids for power generation. The same order also created an International Lake Superior Board of Control composed of the Officer of the Corps of Engineers, charged with the improvements of the falls of the St. Marys River, and an officer appointed by the Canadian Government.

It is the function of the Board to determine the amount of water available for power generation and to maintain as nearly as possible the level of Lake Superior between 602.1 feet and 603.6 feet. Since 1922, the high limit has been maintained within 0.03 feet, and the low limit within approximately 2 feet.

Lake Currents

Surface currents and their patterns in the Great Lakes have been studied for almost a century. As a result, a rather general picture of the circulation is known. That of Lake Superior is shown in Figure 1. This representation is based on work by Harrington (1895) who was the first to undertake a thorough study of the currents of the Great Lakes. While further studies indicate some modification this interpretation is considered valid in its general concept.

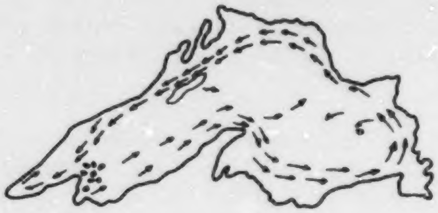


FIGURE 1 — LAKE SUPERIOR WATER CIRCULATION

Since Lake Superior has no flow-through, current patterns result primarily from wind action. The wind-driven current is modified by the rotation of the earth, density differences (temperatures in Lake Superior) and the shape of the basin. In Lake Superior the forces create a cyclonic or counter-clockwise movement--generally an east-west flow along the southern shore and westward flow along the north shore. Millar reports further information in his paper, "Surface Temperatures of the Great Lakes", in the Journal of the Fisheries Research Board of Canada (1952). "Two cyclonic whirls in the east end of the lake, especially the more southerly one, are areas of convergence, and the arm near Duluth is an area of strong convergence. The compensating upwelling is distributed broadly south of a bent line from Devils Isle to Passage Island, then to Marquette, Michigan."

Population

The Michigan portion of the Lake Superior basin contains a population of approximately 165,000 people (1960 census). Of this number 79,715 live in 17 municipalities which had a population of 1,000 or more in 1960. There are two cities in the Michigan portion of the basin which had a 1960 population of more than 10,000 people--Ironwood and Marquette. Based on historical growth rates the population of the area will be approximately 175,000 in 1980. The 1960 population density was less than 20 people per square mile for this area.

Economy

The Upper Peninsula of Michigan, which includes the Lake Superior Basin, has a history of a highly specialized economy. This economy is based on the use of natural resources which provide the raw materials and generate the capital to provide a significant influence on Michigan regional as well as national industrial development. As an example, 850,031,000 long tons of iron ore were produced in Michigan from 1854 to 1964. This concentration of high-value and accessible natural resources, also served by a magnificent water-transportation facility, is unique in the United States. Through the many generations of discovery, exploration, and development of these resources, water transportation on Lake Superior played a major role--and is still providing the link to buying and manufacturing centers.

In 1910, Houghton and Keweenaw counties had more than double their present populations. Many of the mining communities that were thriving at the turn of the century are now virtually ghost towns, as are several former lumbering centers. The decline of mining and logging activities was followed by a decline in wood products industries and, in certain areas, farming. Populations decreased as did the level of the economy. Traditional types of resource development such as shaft mining, sawlog lumbering, unrestrained commercial fishing, and family farming were no longer adequate or profitable. However, the still-great reserve of natural resources was sufficient incentive to encourage the development of new techniques and new methods which are providing a renewed vigor to the economy of Michigan's Lake Superior drainage area. In 1967, 14,033,891 long tons of iron ore were shipped from Michigan mines--almost three million more tons than in 1930. This substantial increase is due mostly to beneficiation (or concentration) of low grade ores. In 1966, 70 percent of the Michigan shipments were concentrates. Further, 75 percent of the ore mined was from open-pit mining operations. In 1967, 58,595 short tons of copper were produced in Michigan--13,000 tons more than in 1940.

The modern economy of the Michigan portion of the Lake Superior drainage area is still dominantly natural resource oriented. The manufacturing activity of the area is in the cities. There are a few locally important agricultural areas. The nine counties in the Michigan portion of the Lake Superior drainage area represent 47 percent of the land area of the Upper Peninsula and 14 percent of the land area of the State of Michigan. This area contained 55 percent of the Upper Peninsula population and 2 percent of the State of Michigan's population in 1960. The "Value Added by Manufacture" in 1964 for this area was 34 percent of the value added by the Upper Peninsula and 0.3 percent of the value added by the entire state. "Retail Trade Sales" in 1964 for this area were 50 percent that of the entire Upper Peninsula and 2 percent that of the entire state. "Wholesale Trade Sales" in 1964 for this area were 40 percent of the sales for the Upper Peninsula and 0.6 percent of sales for the entire state. The amount of "Selected Services" in 1964 for this area was 43 percent that of the Upper Peninsula and 0.9 percent that of the state. The "Value of Farm Products Sold" in 1964 for this area was 40 percent that of the Upper Peninsula and 1 percent that of the state.

An important segment of the economy of the Northern Peninsula of Michigan is that contributed by tourism and recreation. The recent report by the Upper Peninsula Committee on Area Progress Guidelines for Tourism-Recreation in Michigan's Upper Peninsula gives a total figure for tourism activity in 1964 at $118 million.

Agriculture

The fact that agriculture is only locally important in the Michigan portion of the Lake Superior basin is shown by the fact that the "Value of Farm Products Sold" in this area was only $8,093,000 in 1964 as compared to $8,888,000 in 1954, a decrease of 9 percent during a period when the "Value of Farm Products Sold" increased by 10 percent in the Upper Peninsula and by 41 percent in the entire State of Michigan. Dairying was the most important agricultural activity in seven of the nine Michigan counties in the Lake Superior basin. Potato raising was the most important agricultural activity in Marquette County while the production of hay was the most important in Luce County.

Land Use

Land use of the Lake Superior basin ranges from intensive use in the urban areas, such as Marquette, to the use of the forests. Of the nine counties in this area, five are more than 91 percent forested and all of them are over 70 percent forested. Most of the existing forest is of the Maple-Beech-Birch type. Because large acreages of this area are relatively low-value forest land, much of it is publicly owned.

Only a fraction of the land is in farms. Chippewa County with 12.8 percent of its land in farms had the highest percentage of farm land in the nine counties in 1964. Keweenaw County had only 0.2 percent of its land in farms.

WATER USES

The waters of the Lake Superior basin serve a multiplicity of uses. They are used for public and industrial water supply, commercial fishing, commercial navigation, recreation, waste assimilation and cooling.

Public Water Supply

One of the most important uses of Lake Superior water is for public water supply. The waters of Lake Superior are of excellent quality for this purpose, being low in hardness, turbidity, chlorides and temperature and showing no evidence of change from year to year. There are a total of 10 public water supply withdrawals from Lake Superior. These 10 withdrawals serve a total of 18 governmental units with a 1960 population of 51,469. These communities withdraw an average of 6.532 million gallons a day.

Industrial Water Supply

There are six industries which withdraw water from Lake Superior, primarily for process water. These industries withdraw an average of 43 million gallons a day.

Commercial Fishing

One of the principal factors in the location of Indian settlements along the rugged Lake Superior shoreline was the availability of food fishes. Accounts of early explorers carry repeated and enthusiastic observations of the fine quality of Lake Superior fish. The early settlers and traders used fish extensively and it became apparent at an early date that there were possibilities for a commercial fishery. By 1850, westward migration, the beginning of the copper and iron industry and the very rapid growth of mid-western cities created an increasing demand for Lake Superior fish. This demand continued to grow during the rest of the century. In 1885, 4 1/2 million pounds of whitefish were taken but by the turn of the century lake trout were becoming the dominant species. The Lake Superior fishery remained stable for many years. Lake trout, whitefish, chubs, herring, walleye and burbot were the major species. About 1950 the effects of the predaceous sea lamprey began to be felt and in 1962 the fishery was closed to lake trout. Table 1 shows average annual production for selected periods.

TABLE 1

AVERAGE ANNUAL FISH PRODUCTION

WHITEFISH

PERIOD	AVERAGE CATCH/YEAR (LBS.)	GREATEST ANNUAL CATCH (LBS.)	LEAST ANNUAL CATCH (LBS.)
1890-1899	1,727,900	X 3,848,000	1,058,000
1900-1919	554,630	1,513,000	93,000
1920-1939	259,050	442,000	X 79,000
1940-1959	401,800	665,000	198,000
1960-1966	299,571	379,000	156,000
		X Highest recorded year 1891	X Lowest recorded year 1923

LAKE TROUT

PERIOD	AVERAGE CATCH/YEAR (LBS.)	GREATEST ANNUAL CATCH (LBS.)	LEAST ANNUAL CATCH (LBS.)
1890-1899	2,462,400	2,729,000	1,998,000
1900-1919	2,612,511	X 4,331,000	776,000
1920-1939	1,932,500	2,596,000	1,165,000
1940-1956	2,050,294	2,700,000	1,224,000
1957-1962	484,833	849,000	135,000
1963-1966	64,750	67,000	X 62,000
		X Highest recorded year 1904	X Lowest recorded year 1963

Table 1 continued

TOTAL CATCH

1920-1929	2,855,500	3,812,000	X 1,648,000
1930-1939	4,969,100	6,547,000	3,179,000
1940-1949	7,051,700	X 8,438,000	5,868,000
1950-1959	5,751,500	7,558,000	4,647,000
1960-1966	6,603,429	8,352,000	4,587,000
		X Highest recorded year 1941	X Lowest recorded year 1923

Sport Fishing and Hunting

The Lake Superior sport fishery is supported mainly by the variety of fish listed below:

Brook Trout
Northern Pike
Smelt
Lake Trout
Rainbow Trout
Perch
Walleyed Pike
Brown Trout

The fall of 1966 was a bonus for Lake Superior fishermen, for this was when the first coho salmon was taken. This new species, introduced by the Michigan Department of Conservation in the spring of 1966, is being most enthusiastically received by Michigan sportsmen. First Lake Superior plantings were in the Big Huron River of Baraga County. In April of 1967, 600 of the cohos were reported caught in Marquette Harbor and others in Munising Bay. This first success indicates a new and valuable sport fish for Lake Superior.

The waters of Lake Superior and adjacent Michigan land formations provide an appealing flyway route for myriads of North American waterfowl. Opportunities are readily available for both study and hunting since nearly two dozen species of ducks and three species of geese migrate through the area.

Recreation

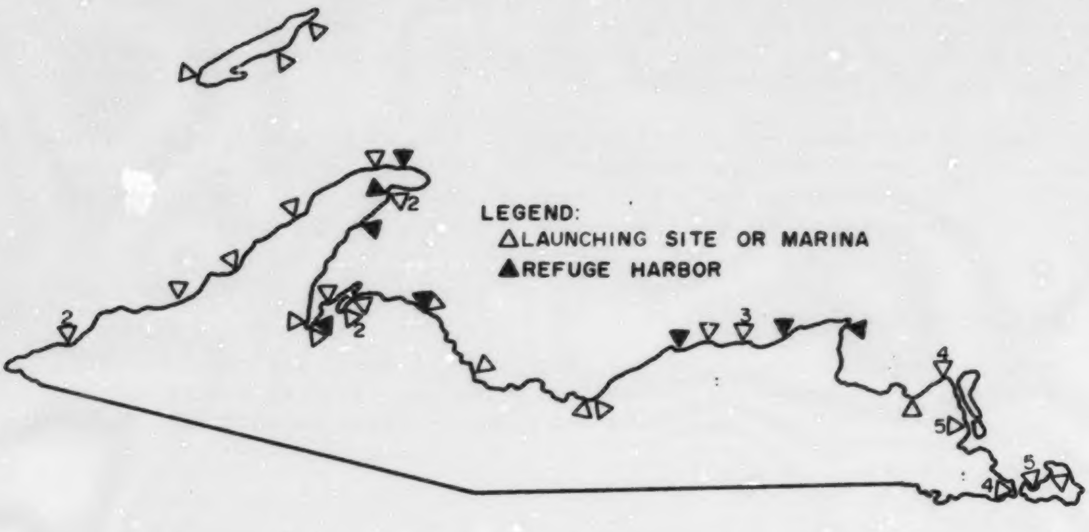
Information extrapolated from Report #4 to the Outdoor Recreation Resources Review Commission entitled "Shoreline Recreation Resources of the United States" specifies that Lake Superior has a total of 730 miles of recreational shoreline in Michigan. Various categories which make up this total include 692 miles of bluff shoreline, 22 miles of marsh shoreline and 16 miles of beach. Two hundred fifty-two miles or 34.5 percent of this shoreline are in public recreation areas.

A well known recreational facility found in Lake Superior is the Isle Royale National Park. The island is unique among national parks in its wilderness setting, cut off from the mainland by many miles of water and associated with more than 200 small islands and countless minor rocks. Isle Royale is the largest island in Lake Superior, being 45 miles long, nine miles wide and covering 210 square miles.

There are 7 state parks and thousands of acres of publicly owned land along Michigan's shore of Lake Superior. These state parks attracted a total of 1,158,581 visitors in 1968. In addition to the state parks there are 7 local parks and beach areas and the recently established Pictured Rocks National Shoreline between Munising and Au Sable Point.

Boating

Pleasure boating has changed from the luxurious cruise vessels of the early 1900's to the many thousands of recreational watercraft of today. The State of Michigan had a total of 438,000 motor-powered craft registered in 1968. In addition, non-motor-powered craft were estimated at 52,000. There are a considerable number of boats registered in other states that use Michigan waters. In order to serve the increasing numbers of watercraft using Lake Superior waters there are a number of marinas, launching sites and harbors of refuge as shown on Map 1.



MAP 1—RECREATIONAL HARBOR FACILITIES

Commerical Navigation

Commercial navigation is of great significance to the past, present, and future economy of the Great Lakes region. In the past, settlement patterns and the location of cities and industrial complexes were either determined by proximity to lake commerce or strongly influenced by it. Much of today's commercial and industrial activity in the Great Lakes region is geared to lake shipments. The potential of the St. Lawrence Seaway is being fulfilled and promises to provide even closer links between the Great Lakes and world markets. With each shipping season there are increases in direct foreign shipments, both to and from Lake ports.

Lake Superior is endowed with more natural good harbors than the other Great Lakes. The north shore and Isle Royale are characterized by many deep water bays and inlets. The south shore has a smoother coast line and is deficient in natural harbors, particularly in the east.

Improvement of navigation facilities paralleled that of the development of the commercial capabilities. Some harbors were developed and docks built at an early date. These were adequate for the type of commerce of the time. As vessel size and craft increased, local capabilities were often not adequate to assume the cost of the improvements. At the direction of Congress, the U.S. Army Corps of Engineers eventually assumed responsibility for harbor and channel improvements.

The amount of freight moved across Lake Superior is great. Nute (1944) reports that by 1935 nearly 2.4 billion tons were moved through the Soo locks. Sixty percent of the tonnage was iron ore. In addition there were 9 billion bushels of grain, over 24 billion board feet of lumber and over 40 million tons of general merchandise.

Since 1935 an additional 3 billion tons of freight have been moved through the locks. The total since the opening of the locks in 1855 through 1966 has been 5 1/2 billion tons, equivalent to over 500,000 ship loads (using average capacity of pre-second World War fleet--approximately 10,500 tons).

Waste Water Discharges

There are only two municipalities, Baraga and L'Anse, and two industries which discharge wastewater directly to Lake Superior. The two industries are Royal Oak Charcoal Company, Marquette and Kimberly Clark Corporation, Munising Mill in Munising

Cooling

The City of Marquette Board of Power and Light is the only Michigan municipally owned facility utilizing Lake Superior for cooling water withdrawals and discharge. There are two industrial users, the U.P. Generating Company at Marquette and the U.P. Power Company at L'Anse.

CHAPTER V

WATER QUALITY MONITORING AND SPECIAL STUDIES

Part 1

BACTERIOLOGICAL MONITORING OF WATERS ALONG LAKE SUPERIOR SHORELINE

The Michigan Water Resources Commission maintains an annual summer sampling program of Michigan's Great Lakes coastline surface waters. Samples collected along the Lake Superior coastline are analyzed for total coliforms by the multiple tube method and results are presented as most probable number (MPN) of total coliform present in the water sample. Bacteriological data presented in Appendix L were obtained in 1967 and 1968. Only the minimum, maximum, and geometric mean values for each sampling location are expressed in this table, however, results for all samples collected and referred to are on file in the Lansing office of the Water Resources Commission.

Of the 14 locations along Michigan's Lake Superior shoreline for which there are 1967 and 1968 data available only one had a geometric mean value for total coliform over 1000 organisms per 100 ml. in 1968 while in 1967 there were no such locations. The data, when examined in detail, reveals a definite rise to peak coliform concentrations and then a decline for each location during the sampling period of June through August.

CHAPTER V
Part 2

TRIBUTARY AND LAKE SUPERIOR MONITORING PROGRAMS

Water quality monitoring of Great Lakes tributary streams was initiated by the Water Resources Commission in May, 1955 to obtain background radioactivity information. The monitoring program has since been expanded to its present level of 41 stations located throughout the state including a station in Lake Superior at Marquette. Results of sampling at this station from 1959 to 1968 are presented in Table 1 of Appendix M.

Beginning in 1963 the monitoring program was expanded to obtain a variety of background data on the quality of water flowing into the Great Lakes and connecting waters via the principal watersheds in Michigan's Lower Peninsula. Seven principal watersheds were sampled once in 1967 and three times in 1968. As of this year (1969) five Lake Superior tributaries are being sampled monthly. These five tributaries are the Montreal, Presque Isle, Ontonagon, Sturgeon and Tahquamenon rivers.

The specific objectives of the program are to determine long-term trends in the chemical, physical and bacteriological characteristics of tributary streams to the Great Lakes in Michigan. The monitoring stations are located as close as possible to the mouths of the drainage basins and below all known sources of waste.

Seven water quality parameters were selected as being indicative of the chemical water quality of the Lake Superior tributaries; dissolved oxygen, biochemical oxygen demand, pH, soluble orthophosphate nitrate nitrogen, chlorides and suspended solids. The data collected during 1967, 1968 and the first two months of 1969 are presented in Figures 1 through 9 of Appendix N. Bacteriological data for 1968 and the first two months of 1969 are shown in Table 2. The monitored tributaries are shown on Map 1.

In addition to the regular monitoring of Lake Superior tributaries the Commission staff has inaugurated a program of sampling of raw water from the Great Lakes. This is done at 10 water treatment plants along the shoreline of Lake Superior. The intent of the program is to establish existing water quality at the various intakes and indicate any trends which occur in the quality. These samples are currently collected annually. The first series was collected in 1967 and these results, along with the 1968 results are shown in Tables 1 and 2 of Appendix O. Sampling locations are presented on Map 1.

In addition to the program conducted by the Water Resources Commission, the Michigan Department of Public Health requires that each water treatment plant submit monthly operating reports which contain results of physical, chemical and bacteriological tests which are made on the raw water supply. The two programs supplement each other and furnish fairly complete documentation of the water quality at water intakes in Lake Superior.

The staff of the Water Resources Commission conducts various surveys throughout the state in accordance with its program of pollution prevention and abatement. One such program is a yearly surveillance of Michigan's interstate rivers. This program was initiated in 1967 with a series of 89 stations located throughout the state. Samples were collected at approximately 4 hour intervals for a 24-hour period at each station. Six of these stations are located on the Montreal River and the 1967 results of this program are presented in Appendix P.

CHAPTER V
Part 3

WATER QUALITY SURVEY OF LAKE SUPERIOR IN THE MARQUETTE VICINITY
August 8-11, 1968

On August 8-11, 1968, a water quality survey was conducted to determine the effects of various wastewater discharges on the biota of Lake Superior and its major tributaries in the Marquette vicinity.

Stream studies found well balanced, clean-water benthic animal communities at all Dead River stations and at the Carp River control station above the Marquette Wastewater Treatment Plant. A very restricted pollution-tolerant benthic community was found below this outfall where profuse slime growths, septic odors and turbid waters were evident.

Productivity of benthic animal life in the sand, sand-rock substrates of Lake Superior was generally low. The shallower inshore areas with unstable substrates supported even lower numbers of benthic animals than the deeper offshore waters.

Some modification of the physical environment and biological community structure of Lake Superior was evident at scattered locations near Marquette. The Upper Peninsula Generating Company cooling water discharge warmed approximately 80 acres of Lake Superior by more than 10°F and approximately 240 acres by more than 5°F. No adverse biological effects from this heated discharge were evident.

However, the entire Dead River flow is cycled through this generating plant for cooling purposes and these waters contribute a natural organic loading to Lake Superior. This natural enrichment has increased the benthic productivity of small offshore area as indicated by an increase in pollution tolerant organisms.

The Royal Oak Charcoal Company, a destructive wood distillation plant, discharges phenolic wastes to Lake Superior. No complaints have been received concerning taste or odors in the Marquette water supply nor are there any records of off flavored fish from the area. No adverse biological effects to benthic animal communities in close proximity to these discharges were detected.

Thin organic sedimentation, evident in the Marquette Harbor vicinity, was enhanced by the quiet protected harbor waters, intensive shoreline development, and extensive boating and shipping use. Oriana Brook, an apparent recipient of some sewage wastes, enters this harbor vicinity. The benthic community in this area contained more species and individuals than the surrounding Lake Superior areas. This is an expression of increased enrichment of these waters, but the lack of increased numbers of pollution tolerant individuals indicates that this enrichment is not excessive.

The Marquette Wastewater Treatment Plant discharge, via the Carp River, has produced a benthic community alteration in the inshore waters of Lake Superior. This alteration is not pronounced but does suggest a lessening of overall water quality of the environment. This decline in water quality was further substantiated by increased turbidity, sewage odors, and blue-green algae growths in the immediate vicinity of the Carp River mouth.

The water quality of Presque Isle and Marquette Harbors was slightly impaired in small, scattered, localized areas. The overall water quality of Lake Superior in this vicinity was not adversely affected by natural or artificial sources (complete survey is contained in Appendix Q).

CHAPTER V
Part 4

BIOLOGICAL SURVEY OF THE ONTONAGON RIVER AND LAKE SUPERIOR, IN THE VICINITY OF ONTONAGON, MICHIGAN
August 15, 1968

On August 15, 1968 a biological survey was conducted on the Ontonagon River and Lake Superior in the vicinity of Ontonagon, Michigan. The two major sources of waste discharge to these waters were the Hoerner-Waldorf Corporation paper mill and the Ontonagon Wastewater Treatment Plant.

The Ontonagon River receives large quantities of red clay from its watershed which results in extremely turbid river waters. Transparency of river water during this study ranged from 1.0 to 1.5 feet. This red clay is transported to Lake Superior where significant reductions in water transparency were measured in the immediate offshore waters.

The Ontonagon Wastewater Treatment Plant discharge did not have any appreciable effect upon benthic animal life in the Ontonagon River. A slight enrichment immediately downstream was expressed in a moderate increase in sludgeworm populations, but the basic benthic community structure at this location was not altered.

A small bay-like area immediately off the Hoerner-Waldorf discharge contained bottom sediments of paper fibers, muck, and oils. No aquatic life was found in this area. However, the papermill effluent exerts little influence, if any, upon the benthos of the Ontonagon River. The wastewater is warmer than the river water and tends to stay near the river's surface while being transported downstream to Lake Superior.

Red clay, plant debris, and other such river transport materials settling to the bottom have enriched the benthos of a small area of Lake Superior off the Ontonagon River mouth. The scope of this enrichment did not appear to be extensive. Organic settleable solids arising from the Ontonagon Wastewater Treatment Plant and the Hoerner-Waldorf paper mill may add somewhat to this condition, but decomposing plant materials from the Ontonagon River were the largest factor (complete survey is contained in Appendix R).

CHAPTER V
Part 5

BIOLOGICAL RECONNAISSANCE SURVEY OF THE FREDA COPPER MILL DISCHARGE TO LAKE SUPERIOR IN THE VICINITY OF FREDA, MICHIGAN

August 24 and 27, 1966

On August 24 and 27, 1966 a biological survey was conducted on Lake Superior in the vicinity of the Freda Copper Mill tailings discharge at Freda, Michigan. An effort was made to determine the effects of this stamp sand discharge upon the benthic fauna and to determine the extent of discoloration of Lake Superior waters by these wastes.

Benthic animal samples collected in the Freda-Redridge vicinity of Lake Superior failed to reveal any useful information concerning the effects of this discharge on the aquatic environment. The shifting sand bottom provided a very poor benthic habitat and a single midge larva was the only benthic animal found in the survey. Plankton samples collected during this survey showed that there were no discernible differences in the various plankton communities sampled.

Considerable discoloration of Lake Superior waters by this stamp sand discharge was evident. Secchi disk readings off the point of discharge were: 6 inches at 10 yards; 2 feet at 30 yards; and 25 feet at 300 yards. A visual red-brown discoloration was observed in Lake Superior for 3/4 miles offshore in the vicinity of Redridge and for five or more miles along the shoreline to the northeast.

Operations at this mill were permanently discontinued in December, 1966. The Company has no plans for reactivating this mill (complete survey is contained in Appendix S).

CHAPTER V
Part 6

A BIOLOGICAL SURVEY OF SOUTH BAY, LAKE SUPERIOR AND OBSERVATIONS ON THE ANNA RIVER, MUNISING, ALGER COUNTY, MICHIGAN
August 6, 1968

In 1957 a biological survey established that the benthic area of South Bay, Lake Superior in close proximity to Munising was biologically depressed. On August 6, 1968 a biological survey was conducted on South Bay and its major tributary the Anna River to determine present water quality conditions and detect any changes in the benthic macrofaunal community that may have occurred since the 1957 survey.

The major sources of wastewater discharge to South Bay are: The Kimberly-Clark Corporation paper mill discharging directly to South Bay; the Munising Wastewater Treatment Plant discharging to the Anna River; and a small community domestic sewage septic tank discharging directly to South Bay.

Studies on fish and benthic animal communities in the Anna River show clean water populations upstream and limited populations downstream from the Munising Wastewater Treatment Plant. The downstream populations are in a very delicate balance with many species barely represented in the fauna. The extremely cold water of the Anna River prevents the organic loading from exerting its full effect upon the biological populations.

A cone-shaped area of degradation was identified in the southern portion of South Bay. This area encompassed approximately one mile of shoreline and extended nearly 4,000 feet into the bay. The benthic community within this area was severly limited and was comprised mainly of pollution tolerant sludgeworms and midges. The remaining portion of South Bay supported a diversified benthic community structure. However, the littoral communities found in the extreme outer bay were much more diverse than those found in the littoral area of the inner bay.

Most bottom sediments of South Bay contained large quantities of bark, wood chips, and woody frass. These materials generally decreased in quantity with increased distance from the southern end of South Bay. Two stations just offshore from Kimberly-Clark contained completely artificial substrates, one entirely of wood chips, the other entirely of paper-mache.

Plankton samples, dissolved oxygen profiles, and inshore measurements of biochemical oxygen demand and suspended solids show no adverse water quality conditions in the water column of South Bay.

It appears that the principal source of degradation of South Bay, Lake Superior, arises from previously deposited woody materials which are still exerting a considerable influence upon the benthic ecology. This is substantiated by data showing almost no change in the benthic community between 1957 and 1968, even though marked improvements were made in paper mill waste control and municipal sewage treatment during that period (complete survey is contained in Appendix T).

CHAPTER VI

CONCLUSIONS

The citizens and government of Michigan are very keenly aware of the value of clean water, both in Lake Superior and in inland lakes and streams. The people have supported, and State government has developed, broad-scale and fast moving programs of pollution control.

Michigan law provides a full and effective statutory basis for preventing and controlling pollution. The State Legislature has repeatedly shown its willingness to enact additional laws as the need for them emerges.

Through its Water Resources Commission, its Department of Public Health and its Geological Survey, Michigan has an aggressive, effective and large-scale program of water pollution control in active operation. The Michigan plan for effectuating this program in 1968-69 has been fully approved by the Secretary of the Interior.

The State has an ongoing and appropriately expanding program of waste disposal surveillance and water quality monitoring which is fully responsive to the needs for detecting and identifying its pollution problems.

The Water Resources Commission and Department of Public Health have amply demonstrated that when pollution problems are identified they can and do take proper corrective action.

The State Legislature has responded to Executive requests for successive increases in State expenditures for pollution control.

Michigan's $335 million clean water bond proposal was approved in November 1968 by Michigan voters by a 2 to 1 margin. This bond program when fully implemented will provide substantial grant assistance to municipalities and townships for the construction of sewage treatment works and for construction of sewer systems to correct improper sewage discharges.

The Water Resources Commission has adopted water quality standards for all waters together with a plan for implementation and enforcement of the interstate standards.

Michigan has only one small municipal wastewater discharge and one industrial and two electric power generating plants which make a direct discharge of wastewaters to Lake Superior. These discharges have only a minor effect on water quality in the immediate area of discharge and with the exception of the municipal discharge are considered to have no pollutional effect on the waters of Lake Superior.

In accordance with the Commission's plan of implementation of its interstate water quality standards, correction of the municipal discharge will be accomplished on or before June 1, 1972.

There are four coastal communities with a combined 1960 population of approximately 29,000 which discharge primary treated and chlorinated effluent into intrastate waters. Again, with the exception of minor effects on water quality in the immediate river mouth areas, these discharges have not been determined to have a pollutional effect on the waters of Lake Superior, except for the phosphorus nutrients added to the lake waters.

One industrial discharge into intrastate waters, near the mouth, has been determined to result in occasional taste and odor problems in a Lake Superior community water supply. A corrective program is being pursued with this industry and it is fully expected that a timely schedule will be developed for an early solution to the problem.

The Michigan agencies recognize the pollution problems on waters tributary to Lake Superior and have in operation aggressive programs for their full and timely correction. The present deficiencies in waste treatment at inland locations do not contribute to pollutional conditions in Lake Superior except as a residual phosphorus loading carries on down to the lake.

The Water Resources Commission recognizes the phosphorus problem in accelerating stream and lake water enrichment, and has adopted a state-wide policy and comprehensive program for phosphate removal from waste discharges, with scheduled early completion dates.

APPENDIX A

ACT 245, PUBLIC ACTS OF 1929, AS AMENDED

State of Michigan

WATER RESOURCES COMMISSION

Act 245, Public Acts of 1929, as amended *

An act to create a water resources commission to protect and conserve the water resources of the state, to have control over the pollution of any waters of the state and the Great Lakes, to have control over the alteration of the watercourses and the flood plains of all rivers and streams, with powers to make rules and regulations governing the same, and to prescribe the powers and duties of such commission; to prohibit the pollution of any waters of the state and the Great Lakes; and to prohibit the obstruction of the floodways of the rivers and streams of the state; to designate the commission as the state agency to cooperate and negotiate with other governments and agencies in matters concerning the water resources of the state; and to provide penalties for the violation of this act.

Sec. 1. For the purpose of carrying out the provisions of this act there is hereby created a water resources commission, hereinafter referred to as the commission, which shall consist of the director of conservation, the commissioner of health, the highway commissioner, the director of agriculture, and 3 citizens of the state to be appointed by the governor, by and with the advice and consent of the senate, 1 from groups representative of industrial management, 1 from groups representative of municipalities, and 1 from groups representative of conservation associations or interests, for terms of 3 years each except that of the members first appointed, 1 shall be appointed for a term of 1 year, 1 for a term of 2 years, and 1 for a term of 3 years. Vacancies shall be filled for the unexpired term in the same manner as original appointments. Members of the commission shall be entitled to actual and necessary expenses incurred in the performance of official duties. It shall be the duty of the department of administration to provide suitable office facilities for the use of the commission.

Each of the aforesaid state officers is hereby authorized to designate a representative from his department to serve in his stead as a member of the commission for 1 or more meetings.

Sec. 2. The commission shall organize and make its own rules and regulations and procedure and shall meet at least once each month and shall keep a record of its proceedings. The commission shall protect and conserve the water resources of the state and shall have control of the pollution of surface or underground waters of the state of Michigan and the great lakes, which are or may be affected by waste disposal of municipalities, industries, public or private corporations, individuals, partnership associations, or any other entity. The commission is empowered to make or cause to be made surveys, studies and investigations of the uses of waters of the state, both surface and underground, and to cooperate with other governments, governmental units and agencies thereof in making such surveys, studies and investigations. The commission shall assist in an advisory capacity any flood control district which may be authorized by the legislature of this state. The commission in the public interest shall have the right and duty to appear and present evidence, reports and other testimony during the hearings involving the creation and organization of flood control districts. It shall also be the duty and responsibility of the commission to advise and consult with the legislature on the obligation of the state to participate in the costs of construction and maintenance as provided for in the official plans of any flood control district or intercounty drainage district. The commission shall have authority to, and shall enforce the provisions of this act and shall make and promulgate such rules and regulations as shall be deemed necessary to carry out the provisions of this act. The rules and regulations of the commission shall be promulgated in conformity with the provisions of Act No. 88 of the Public Acts of 1943, as amended, being sections 24.71 to 24.82, inclusive, of the Compiled Laws of 1948.

Sec. 2a. The water resources commission is designated the state agency to cooperate and negotiate with other governments, governmental units and agencies thereof in matters concerning the water resources of the state, including but not limited to flood control and beach erosion control. The commission shall have control over the alterations of natural or present watercourses of all rivers and streams in the state to assure that the channels and the portions of

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* Amended by Act 117, P.A. 1949, effective May 18, 1949; Act 165, P.A. 1963, effective September 6, 1963; Act 405, P.A. 1965, effective October 29, 1965; Act 167, P.A. 1968, effective June 17, 1968; and Act 209, P.A. 1968, effective July 1, 1969 (Sec. 6a.).

od plains that are the floodways are not inhabited and are kept free and clear of inter-
or obstruction which will cause any undue restriction of the capacity of the floodway.
mission is further authorized to take such steps as may be necessary to take advantage of any act of congress heretofore or hereafter enacted which may be of assistance in carrying out the purposes of this act.

The commission shall report to the governor and to the legislature at least once in each year any plans or projects being carried on or considered and shall include in such report requests for any legislation needed to carry out any proposed projects or agreements made necessary thereby, together with any requests for appropriations.

Sec. 3. The commission shall be authorized to bring any appropriate action in the name of the people of the state of Michigan, either at law or in chancery as may be necessary to carry out the provisions of this act, and to enforce any and all laws relating to the pollution of the waters and the obstruction of the floodways of the rivers and streams of this state. Whenever the attorney general deems it necessary, he shall take charge of and prosecute all criminal cases arising under the provisions of this act.

Sec. 4. The commission or any agent duly appointed by it shall have the right to enter at all reasonable times in or upon any private or public property for the purpose of inspecting and investigating conditions relating to the pollution of any waters and the obstruction of the floodways of the rivers and streams of this state. The commission shall have the right to call upon any officer, board, department, school, university, or other state institution and the officers or employees thereof for any assistance deemed necessary to the carrying out of this act.

Sec. 5. The commission shall establish such pollution standards for lakes, rivers, streams and other waters of the state in relation to the public use to which they are or may be put, as it shall deem necessary. It shall have the authority to ascertain and determine for record and in making its order what volume of water actually flows in all streams, and the high and low water marks of lakes and other waters of the state, affected by the waste disposal or pollution of municipalities, industries, public and private corporations, individuals, partnership associations, or any other entity. It shall have authority to make regulations and orders restricting the polluting content of any waste material or polluting substance discharged or sought to be discharged into any lake, river, stream, or other waters of the state. It shall have the authority to take all appropriate steps to prevent any pollution which is deemed by the commission to be unreasonable and against public interest in view of the existing conditions in any lake, river, stream, or other waters of the state.

Sec. 5a. The commission shall have the authority to make regulations and orders for the prevention of harmful interference with the discharge and stage characteristics of streams. It shall have the authority to ascertain and determine for record and in making its order the location and extent of flood plains, stream beds and channels and the discharge and stage characteristics of streams at various times and circumstances.

Sec. 5b. It shall be unlawful for any person to occupy or permit the occupation, for residential, commercial or industrial purposes of lands or to fill or grade or permit the filling or grading for any purposes other than agricultural, of lands in the flood plains, stream bed or channel of any stream, as ascertained and determined for record by the commission, or to undertake or engage in any activity on or with respect to the lands which is determined by the commission to harmfully interfere with the discharge or stage characteristics of a stream, unless the occupation, filling, grading, or other activity shall have been permitted by an order or rule of the commission, or by a valid permit issued therefor by the department of conservation under the provisions of law.

Sec. 6. (a) It shall be unlawful for any person directly or indirectly to discharge into the waters of the state any substance which is or may become injurious to the public health, safety or welfare; or which is or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life or plants or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired.

(b) The discharge of any raw sewage of human origin, directly or indirectly into any of the waters of the state shall be considered prima facie evidence of the violation of section

6 (a) of this act unless said discharge shall have been permitted by an order, rule or regulation of the commission. Any city, village or township which permits, allows or suffers the discharge of such raw sewage of human origin into any of the waters of the state by any of its inhabitants or persons occupying lands from which said raw sewage originates, shall be subject only to the remedies provided for in section 7 of this act.

(c) Whenever a court of competent jurisdiction in this state shall have ordered the installation of a sewage disposal system in any township, and the plans therefor shall have been prepared, and approved by the state health commissioner, the township shall have authority to issue and sell the necessary bonds for the construction and installation thereof, including the disposal plant and such intercepting and other sewers as may be necessary to permit the effective operation of such system. Such bonds shall be issued in the same manner as provided for in Act No. 320 of the Public Acts of 1927, being sections 123.241 to 123.253 of the Compiled Laws of 1948, or any other act providing for the issuance of bonds in townships.

(d) Any violation of any provision of section 6 shall be prima facie evidence of the existence of a public nuisance and in addition to the remedies provided for in this act may be abated according to law in an action brought by the attorney general in a court of competent jurisdiction.

Sec. 6a. On and after July 1, 1969, or such subsequent date as the commission may designate, every industrial or commercial entity which discharges liquid wastes into any public lake or stream shall have waste treatment facilities under the specific supervision and control of persons who have been certified by the commission as properly qualified to operate the facilities. The commission shall examine all supervisory personnel having supervision and control of the facilities and certify the persons properly qualified to operate or supervise the facilities. Such a certified person shall file monthly, or at such longer intervals as the commission may designate, on forms provided by the commission, reports showing the effectiveness of the treatment facility operation and the quantity and quality of liquid wastes discharged into the public lake or stream. A person who knowingly makes a false statement in such report may have his certificate as an approved treatment facility operator revoked.

Sec. 7. Whenever in the opinion of the commission any person shall violate or is about to violate the provisions of this act, or fails to control the polluting content or substance discharged or to be discharged into any waters of the state, the commission may notify the alleged offender of such determination by the commission. Said notice shall contain in addition to a statement of the specific violation which the commission believes to exist, a proposed form of order or other action which it deems appropriate to assure correction of said problem within a reasonable period of time and shall set a date for a hearing on the facts and proposed action involved, said hearing to be scheduled not less than 4 weeks or more than 8 weeks from the date of said notice of determination. Extensions of the date of hearing may be granted by the commission or on request. At such hearing any interested party may appear, present witnesses and submit evidence. Following such hearing, the final order of determination of the commission upon such matter shall be conclusive, unless reviewed in accordance with the provisions of the administrative procedures of Act No. 197 of the Public Acts of 1952, as amended, being sections 24.101 to 24.110 of the Compiled Laws of 1948, or any amendment thereto in the circuit court for the county of Ingham, in or for the county in which such person resides, or for the county in which the violation occurred, upon petition therefor filed within 15 days after the service upon said person of the final order of determination.

Sec. 8. (a) Whenever any person shall feel himself aggrieved by the restriction of polluting content, waste or pollution, or any other order of the commission, he shall have a right to file a sworn petition with the commission, setting forth the grounds and reasons for his complaint and asking for a hearing of the matter involved. The commission shall thereupon fix the time and place for such hearing and shall notify the petitioner thereof. At such hearing the petitioner and any other interested party may appear, present witnesses and submit evidence. Following such hearing, the final order of determination of the commission upon such matter shall be conclusive unless reviewed in accordance with the provisions of the administrative procedures of Act No. 197 of the Public Acts of 1952, as amended, being sections 24.101 to 24.110 of the Compiled Laws of 1948, or any amendment thereto in the circuit court for the county of Ingham, or for the county in which such person resides, or for the county in which the alleged violation occurred.

(b) On and after May 18, 1949, any person requiring a new or substantial increase over and above the present use now made of the waters of the state for sewage or waste disposal purposes shall file with the commission a written statement setting forth the nature of the enterprise or development contemplated, the amount of water required to be used, its source, the proposed point of discharge of the wastes into the waters of the state, the estimated amount so to be discharged, and a fair statement setting forth the expected bacterial, physical, chemical and other known characteristics of the wastes. Within 60 days of receipt of the statement, the commission shall make an order stating such minimum restrictions as in the judgment of the commission may be necessary to guard adequately against such unlawful uses of the waters of the state as are set forth in section 6. If the order is not acceptable to the user, he may request a hearing on the matter involved, following which the commission's final order of determination in this connection shall be conclusive unless reviewed in accordance with the provisions of the administrative procedures of Act No. 197 of the Public Acts of 1952, as amended, being sections 24.101 to 24.110 of the Compiled Laws of 1948, or any amendment thereto in the circuit court for the county of Ingham, in or for the county in which the user resides, or for the county in which the use is contemplated, upon petition therefor filed within 15 days after service upon said user of the final order of determination.

Sec. 9. Any duly appointed agent of the commission shall have authority to enforce the provisions of this act and may make criminal complaint against any person violating the same. After service of a written notice of determination, setting forth specifically any violation of this act, any person who shall fail to comply with the order of the commission shall be subject to the penalties of this act.

Sec. 10. Any person, except a municipality, who discharges any substance into the waters of the state contrary to the provisions of section 6 or who fails to comply with any restriction, regulation or final order of determination of the commission made under the provisions of this act shall be guilty of a misdemeanor and upon conviction thereof shall be punished by a fine of not less than $500.00 and in the discretion of the court it may impose an additional fine of not less than $500.00 per day for any number of days during which such violation occurred: Provided, however, That such person shall not be subject to the penalties of this section if the discharge of the effluent is in conformance with and obedient to a rule, regulation or order of the commission. In addition to the minimum fine herein specified, the attorney general, at the request of the department of conservation, is authorized to file a suit in any court of competent jurisdiction to recover the full value of the injuries done to the natural resources of the state by such violation.

Sec. 11. Wherever the word "person" is used in this act, it shall be construed to include any municipality, industry, public or private corporation, co-partnership, firm or any other entity whatsoever. Wherever the words "waters of the state" shall be used in this act, they shall be construed to include lakes, rivers and streams and all other water courses and waters within the confines of the state and also the great lakes bordering thereon.

Sec. 12. This act shall not be construed as repealing any of the provisions of the law governing the pollution of lakes and streams, but shall be held and construed as ancillary to and supplementing the same and in addition to the laws now in force, except as the same may be in direct conflict herewith. This act shall not be construed as applying to copper or iron mining operations, whereby such operations result in the placement, removal, use or processing of copper or iron mineral tailings or copper or iron mineral deposits from such operations being placed in inland waters on bottom lands owned by or under the control of the mining company and only water which may contain a minimal amount of residue as determined by the water resources commission resulting from such placement, removal, use or processing being allowed or permitted to escape into public waters; or applying to the discharge of water from underground iron or copper mining operations subject to a determination by the water resources commission.

Sec. 12a. The provisions of this act shall be construed as supplemental to and in addition to the provisions of Act No. 316 of the Public Acts of 1923, as amended, being sections 261.1 to 277.10, inclusive, of the Compiled Laws of 1948; and nothing in this act shall be construed to amend or repeal any law of the state of Michigan relating to the public service commission, the department of conservation and the department of health relating to waters and water structures, or any act or parts of acts not inconsistent with the provisions of this act.

APPENDIX B

POLLUTION FROM WATERCRAFT

DEPARTMENT OF CONSERVATION

WATER RESOURCES COMMISSION

POLLUTION FROM WATERCRAFT

Filed with Secretary of State, April 22, 1968

(By authority conferred on the water resources commission by sections 2 and 5 of Act No. 245 of the Public Acts of 1929, as amended, being sections 323.2 and 323.5 of the Compiled Laws of 1948.)

R 323.501. Definitions.

Rule 501. (1) "Act" means Act No. 245 of the Public Acts of 1929, as amended, being sections 323.1 to 323.12a of the Compiled Laws of 1948, and the act which these rules implement.

(2) "Commission" means the Water Resources Commission of the Department of Conservation.

(3) "Litter" means bottles, glass, crockery, cans, scrap metal, junk, paper, plastic, garbage, rubbish or similar refuse discarded as no longer useful or usable.

(4) "Marine toilet" means a toilet on or in a watercraft.

(5) "Nonpollutional" means incapable of causing unlawful pollution as defined in section 6 of the act, as amended.

(6) "Sewage" means human body wastes, treated or untreated.

(7) "Watercraft" means a contrivance used or capable of being used for navigation upon water whether or not capable of self-propulsion, except a passenger or cargo-carrying vessel including those subject to the Interstate Quarantine Regulations of the United States Public Health Service adopted pursuant to sections 241, 243, 252 and 262 to 272 of Title 42 of the United States Code.

R 323.502. Sewage; use of pollution control devices and disposal facilities.

Rule 502. (1) No person shall operate a marine toilet on a watercraft on the waters of this state so as to discharge sewage into such waters unless the sewage has been rendered nonpollutional by passage through a device approved by the commission.

(2) No person owning or operating a watercraft having a marine toilet shall use or permit the use of such toilet on the waters of this state unless the toilet is equipped with 1 of the following pollution control devices:

(a) A holding tank which will retain all sewage produced on the watercraft.

(b) An incinerating device which will reduce to ash all sewage produced on the watercraft.

(c) A device determined by the commission to be capable of rendering the sewage discharges nonpollutional in accordance with the requirements of the act.

(3) No person shall dispose of sewage accumulated in a holding tank or any other container on a watercraft in such manner that the sewage reaches or may reach the waters of this state except through a sewage disposal facility approved by the state Department of Public Health or its designated representative.

R 323.503. Watercraft registration; marine toilet information.

Rule 503. An applicant for a certificate of number for a watercraft pursuant to section 33 of Act No. 303 of the Public Acts of 1967, being section 281.1033 of the Compiled Laws of 1948, shall disclose at such time to the commission whether the watercraft has in or on it a marine toilet, and if so, whether the toilet is equipped with a pollution control device as required by these rules. The commission may request the secretary of state to provide it with the name of an applicant whose application indicates the absence of such pollution control device on a marine toilet.

R 323.504. Litter disposal.

Rule 504. Disposal of litter is subject to the provisions of Act No. 106 of the Public Acts of 1963, as amended, being sections 752.901 to 752.906 of the Compiled Laws of 1948.

R 323.509. Effective date.

Rule 509. These rules are effective January 1, 1970.

APPENDIX C

MICHIGAN'S INTERSTATE WATER QUALITY STANDARDS

WATER QUALITY STANDARDS
FOR
MICHIGAN'S INTERSTATE WATERS

State of Michigan
Water Resources Commission
Department of Natural Resources
Adopted June 1967

COMMISSION OBJECTIVE:

WATERS IN WHICH THE EXISTING QUALITY IS BETTER THAN THE ESTABLISHED STANDARDS ON THE DATE WHEN SUCH STANDARDS BECOME EFFECTIVE WILL NOT BE LOWERED IN QUALITY BY ACTION OF THE WATER RESOURCES COMMISSION UNLESS AND UNTIL IT HAS BEEN AFFIRMATIVELY DEMONSTRATED TO THE MICHIGAN WATER RESOURCES COMMISSION AND THE DEPARTMENT OF THE INTERIOR THAT THE CHANGE IN QUALITY WILL NOT BECOME INJURIOUS TO THE PUBLIC HEALTH, SAFETY, OR WELFARE, OR BECOME INJURIOUS TO DOMESTIC, COMMERCIAL, INDUSTRIAL, AGRICULTURAL, RECREATIONAL OR OTHER USES WHICH ARE BEING MADE OF SUCH WATERS, OR BECOME INJURIOUS TO THE VALUE OR UTILITY OF RIPARIAN LANDS; OR BECOME INJURIOUS TO LIVESTOCK, WILD ANIMALS, BIRDS, FISH, AQUATIC LIFE OR PLANTS, OR THE GROWTH OR PROPAGATION THEREOF BE PREVENTED OR INJURIOUSLY AFFECTED; OR WHEREBY THE VALUE OF FISH AND GAME MAY BE DESTROYED OR IMPAIRED, AND THAT SUCH LOWERING IN QUALITY WILL NOT BE UNREASONABLE AND AGAINST PUBLIC INTEREST IN VIEW OF THE EXISTING CONDITIONS IN ANY INTERSTATE WATERS OF MICHIGAN.

WATER WHICH DOES NOT MEET THE STANDARDS WILL BE IMPROVED TO MEET THE STANDARDS.

WATER

PARAMETERS WATER USES	1 COLIFORM GROUP (organisms/100ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A **WATER SUPPLY** (1) **DOMESTIC** Such as drinking, culinary and food processing.	For Great Lakes & Connecting Waters: The monthly average shall not exceed 2000 nor shall 20% of the samples examined exceed 2000 For Inland Waters: The monthly average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating Solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l Chromium6: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-B
(2) **INDUSTRIAL** Such as cooling and manufacturing process.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
B **RECREATION** (1) **TOTAL BODY CONTACT** Such as swimming, water skiing and skin diving.	The average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 100. See Appendix A, Section B	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
(2) **PARTIAL BODY CONTACT** Such as fishing, hunting, trapping and boating.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000. See Appendix A, Section B.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use
C **FISH, WILDLIFE AND OTHER AQUATIC LIFE** such as growth and propagation	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	At the average low river flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained for: Intolerant fish - cold water species: Not less than 6 at any time. Intolerant fish - warm water species: Average daily DO not less than 5, nor shall any single value be less than 4 Tolerant fish - warm water species: Average daily DO not less than 4, nor shall any single value be less than 3 At greater flows the DO shall be in excess of these values	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency
D **AGRICULTURAL** Such as livestock watering, irrigation and spraying.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Not less than 3 at any time	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use
E **COMMERCIAL** Such as navigation, hydroelectric and steam generated electric power.	The average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The average fecal coliform density for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use	Floating solids: None of unnatural origin Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease	Limited to concentrations less than those which are or may become injurious to the designated use

* For the Great Lakes and connecting waters no heat shall be discharged in quantities to create conditions which are or may become injurious to the public health, safety or welfare; or which are or may become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being or may be made of such waters; or which are or may become injurious to the value or utility of riparian lands; or which are or may become injurious to livestock, wild animals, birds, fish or aquatic life or the growth or propagation thereof.

QUALITY STANDARDS

TOTAL DISSOLVED SOLIDS (mg/l) 6	NUTRIENTS 7 Phosphorus, ammonia, nitrates and sugars	TASTE & ODOR PRODUCING SUBSTANCES 8	TEMPERATURE* (°F) 9	HYDROGEN ION (pH) 10	RADIOACTIVE MATERIALS 11
FOR GREAT LAKES & CONNECTING WATERS: **Total Dissolved Solids:** The maximum shall not exceed 200. **Chlorides:** The monthly average shall not exceed 50. A monthly average of 10 is a desirable limit where existing conditions are less than 10. **FOR INLAND WATERS:** **Total Dissolved Solids:** Shall not exceed 500 as a monthly average, nor exceed 750 at any time. **Chlorides:** The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.002 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 10°F	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. **Chlorides:** The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taints in the flesh of fish or game.	Ambient / Allowable increase / Maximum limit Intolerant fish - cold water species: 32° to nat. max. / 10° / 70° Intolerant fish - warm water species: 32° to 55° / 15°; 56° to nat. max. / 10° / 85° Tolerant fish - warm water species: 32° to 59° / 15°; 60° to nat. max. / 10° / 87°	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0).	Standards to be established when information becomes available on deleterious effects.
Less than 700 dissolved minerals. Maximum percentage of sodium 60% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ when the bases are expressed as milliequivalents per liter.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range.	Standards to be established when information becomes available on deleterious effects.

APPENDIX D

MICHIGAN'S INTRASTATE WATER QUALITY STANDARDS

WATER QUALITY STANDARDS
FOR
MICHIGAN'S INTRASTATE WATERS

State of Michigan
Water Resources Commission
Department of Natural Resources
Adopted January 1, 1968

[illegible]

Waters in which the existing quality is better than the established standards on the date when such standards become effective will not be lowered in quality by action of the Water Resources Commission unless and until it has been affirmatively demonstrated to the Michigan Water Resources Commission that the change in quality will not become injurious to the public health, safety, or welfare, or become injurious to domestic, commercial, industrial, agricultural, recreational or other uses which are being made of such waters, or become injurious to the value or utility of riparian lands, or become injurious to livestock, wild animals, birds, fish, aquatic life or plants, or the growth or propagation thereof be prevented or injuriously affected, or whereby the value of fish and game may be destroyed or impaired, and that such lowering in quality will not be unreasonable and against public interest in view of the existing conditions in any intrastate waters of Michigan.

Water which does not meet the standards will be improved to meet the standards.

PARAMETERS / WATER USES	1 COLIFORM GROUP (organisms/100ml or MPN)	2 DISSOLVED OXYGEN (mg/l)	3 SUSPENDED, COLLOIDAL & SETTLEABLE MATERIALS	4 RESIDUES (Debris and material of unnatural origin and oils)	5 TOXIC & DELETERIOUS SUBSTANCES
A **WATER SUPPLY** (1) **DOMESTIC** Such as drinking, culinary and food processing.	The monthly geometric average shall not exceed 5000 nor shall 20% of the samples examined exceed 5000, nor exceed 20,000 in more than 5% of the samples.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards except: Cyanide: Normally not detectable with a maximum upper limit of 0.2 mg/l. Chromium: Normally not detectable with a maximum upper limit of 0.05 mg/l. Phenol: Limitations as defined under A-B.
(2) **INDUSTRIAL** Such as cooling and manufacturing process.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
B **RECREATION** (1) **TOTAL BODY CONTACT** Such as swimming, water skiing and skin diving.	The geometric average of any series of 10 consecutive samples shall not exceed 1000 nor shall 20% of the samples examined exceed 5,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 100.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
(2) **PARTIAL BODY CONTACT** Such as fishing, hunting, trapping and boating.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Present at all times in sufficient quantities to prevent nuisance.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.
C **FISH, WILDLIFE AND OTHER AQUATIC LIFE** such as (growth and propagation)	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	At the average low flow of 7-day duration expected to occur once in 10 years the following DO values shall be maintained in rivers capable of supporting: Intolerant fish, cold-water species (trout, salmon) - Not less than 6 at any time. Intolerant fish, warm-water species (bass, pike, panfish) - Average daily DO not less than 5, nor shall any single value be less than 4. Tolerant fish (carp, bullheads) - Average daily DO not less than 4, nor shall any single value be less than 3. Principal anadromous fish migration in warm-water rivers - Not less than 5 during migration. At greater flows the DO shall be in excess of these values. For lakes see discussion.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Not to exceed 1/10 of the 96-hour median tolerance limit obtained from continuous flow bio-assays where the dilution water and toxicant are continuously renewed except that other application factors may be used in specific cases when justified on the basis of available evidence and approved by the appropriate agency.
D **AGRICULTURAL** Such as livestock watering, irrigation and spraying.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Not less than [illegible] at any time.	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Conform to current USPHS Drinking Water Standards as related to toxicants. Toxic and deleterious substances shall be less than those which are or may become injurious to the designated use.
E **COMMERCIAL AND OTHER** Such as navigation, hydroelectric and steam generated electric power and uses not included elsewhere in these standards.	The geometric average of any series of 10 consecutive samples shall not exceed 5000 nor shall 20% of the samples examined exceed 10,000. The fecal coliform geometric average for the same 10 consecutive samples shall not exceed 1000.	Average daily not less than 2.5, nor any single value less than [illegible]	No objectionable unnatural turbidity, color, or deposits in quantities sufficient to interfere with the designated use.	Floating solids: None of unnatural origin. Residues: No evidence of such material except of natural origin. No visible film of oil, gasoline or related materials. No globules of grease.	Limited to concentrations less than those which are or may become injurious to the designated use.

QUALITY STANDARDS

6 TOTAL DISSOLVED SOLIDS (mg/l)	7 NUTRIENTS Phosphorus, ammonia, nitrates and sugars	8 TASTE & ODOR PRODUCING SUBSTANCES	9 TEMPERATURE (°F)	10 HYDROGEN ION (pH)	11 RADIOACTIVE MATERIALS
Total Dissolved Solids: Shall not exceed [illegible] as a monthly average, nor exceed 750 at any time. Chlorides: The monthly average shall not exceed [illegible], nor shall any single value exceed [illegible].	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent adverse effects on water treatment processes or the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use. Monthly average phenol concentration less than 0.001 mg/l - maximum concentration limited to 0.005 mg/l for a single sample.	The maximum natural water temperature shall not be increased by more than 10°F.	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources.	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Total Dissolved Solids: Shall not exceed 500 as a monthly average nor exceed 750 at any time. Chlorides: The monthly average shall not exceed 125.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.3 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	90°F maximum	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects
Standards to be established when information becomes available on deleterious effects.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use.	Concentrations of substances of unnatural origin shall be less than those which are causing or may cause taint in the flesh of fish or game.	In rivers capable of supporting — Ambient / Allowable increase / Maximum limit Intolerant fish, cold-water species (trout): 32° to nat. max. / 10° / 70° Intolerant fish, warm-water species (bass): 32° to 55° / 15°; 56° to nat. max. / 10° / 86° Tolerant fish, warm-water species (carp): 32° to 59° / 15°; 60° to nat. max. / 10° / 87° For estuaries, fish migrations and unique [illegible] see [illegible].	Maintained between 6.5 and 8.8 with a maximum artificially induced variation of 1.0 unit within this range. Changes in the pH of natural waters outside these values must be toward neutrality (7.0).	Standards to be established when information becomes available on deleterious effects.
Less than 700 dissolved minerals. Maximum percentage of sodium 60% as determined by the formula $\frac{(Na \times 100)}{(Na+Ca+Mg+K)}$ when the bases are expressed as milliequivalents per liter.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use. NO_3 concentrations shall conform to USPHS Drinking Water Standards.	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use.	Not applicable	pH shall not have an induced variation of more than 0.5 unit as a result of unnatural sources	An upper limit of 1000 picocuries/liter of gross beta activity (in absence of alpha emitters and Strontium-90). If this limit is exceeded the specific radionuclides present must be identified by complete analysis in order to establish the fact that the concentration of nuclides will not produce exposures above the recommended limits established by the Federal Radiation Council.
Limited to concentrations less than those which are or may become injurious to the designated use.	Nutrients originating from industrial, municipal, or domestic animal sources shall be limited to the extent necessary to prevent the stimulation of growths of algae, weeds and slimes which are or may become injurious to the designated use	Concentrations of substances of unnatural origin shall be less than those which are or may become injurious to the designated use	The maximum natural water temperature shall not be increased by more than 10°F	Maintained within the range 6.5-8.8 with a maximum induced variation of 0.5 unit within this range	Standards to be established when information becomes available on deleterious effects.

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APPENDIX E

STANDARD FORMS FOR WASTEWATER TREATMENT PLANT REPORTING AND FREQUENCY OF ANALYSIS

WASTEWATER TREATMENT - STANDARD FORMS

All municipalities are required to submit reports monthly on the operation of treatment works. Standard report forms are provided by the Department and each municipality is advised as to the minimum information to be reported and the frequency (number of days per week) of reporting. Included are both physical data and laboratory analyses to establish loadings on the plant, performance of plant units, and the volume and characteristics of the plant effluent. Report forms are presently being revised to include chemical analyses, including phosphorus data. Such information is used to determine effectiveness of overall plant performance, deficiencies of component facilities, capacity reserves for additional loadings, and operational problems and shortcomings. Action is taken to assist in corrective measures and to require correction. The following is a listing of standard forms provided by the department.

Chlorination Record Wastewater Treatment Plant

Operation Report of Wastewater Treatment Plant - Miscellaneous Data
Operation Report of Wastewater Treatment Plant - Primary Treatment Data
Operation Report of Wastewater Treatment Plant - Trickling Filter Data
Operation Report of Wastewater Treatment Plant - Activated Sludge Data
Operation Report of Wastewater Treatment Plant - Intermittent Sand Filter Data
Operation Report of Wastewater Treatment Plant - Chemical Analyses

Operation Report of Sewage Treatment Plant - Digester and Sludge Data
Operation Report of Sewage Treatment Plant - Vacuum Filter and Incineration Data

Operation Report of Waste Stabilization Lagoons
Operation Report of Waste Stabilization Lagoons - Laboratory Data

Waste Stabilization Lagoons - Supplemental Remarks Sheet

APPENDIX F

POLICY ON PRIVATELY-OWNED SEWERAGE SYSTEMS SERVING THE PUBLIC

GEORGE ROMNEY, Governor
R. GERALD RICE, M.D., Director

STATE OF MICHIGAN
DEPARTMENT OF PUBLIC HEALTH
3500 N. LOGAN, LANSING, MICHIGAN 48914

December 4, 1968

DEPARTMENT LETTER NO. 35-3

TO : Bureau Chiefs
Directors of Local Health Departments
Consulting Engineers

FROM : John E. Vogt, Chief
Division of Engineering

SUBJECT : Privately-Owned Sewerage Systems Serving the Public

Today virtually all sewer systems serving residential developments in Michigan are owned and operated by a municipality, village, city, township, county or authority. Recently requests have been received from private corporations for approval of sewer systems and wastewater treatment works in certain unincorporated areas of the State. Questions have been raised as to the conditions and requirements governing the ownership and operation of such systems by a private corporation.

The authority and duties of the Director of the Department in matters relating to the design, construction and operation of all sewer systems and related treatment works are clearly set forth in Act 98, Public Acts of 1913 as amended. Requirements for the submission of plans and specifications for the proposed facilities, the examination thereof by the Department, the issuance of construction permits, the supervisory and visitorial powers, the certification of operators of treatment works as to competency and the issuance of recommendations and orders all are for the declared purpose of protecting the public health and to see that the systems and works are "properly planned, constructed and operated so as to prevent unlawful pollution of the streams, lakes and other water resources of the State." A companion statute, Act 245, Public Acts of 1929 as amended, prescribes the powers and duties of the Water Resources Commission, defines unlawful pollution and, among other things, authorizes the establishment of pollution standards. The 1965 amendment (Act 405, Public Acts of 1965) to this statute places the responsibility upon townships, villages and cities for pollution caused by the discharge of raw sewage of human origin by inhabitants or persons who occupy lands from which said raw sewage originates.

Effective administration requires that the provisions of these two statutes be considered together and so effectuated.

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It is inherent in the provisions of both statutes and a well established principle in Michigan that both the sewer system and treatment works serving the public be operated and maintained in an effective manner continuously at all times and that adequate provision be made for continuity of operation. Act 98, Public Acts of 1913, requires that the applicant for the construction permit submit "a full and fair statement of how the same is to be operated."

Consistent with the statutory provisions and long established principles relating to the public interest, the following policies and procedures are hereby adopted for the planning, construction and operation of sewer systems and related treatment works proposed by private corporations to serve the public:

A. The PRIVATE CORPORATION planning to construct, own and operate such facilities shall:

   1. Submit evidence to the Director of the Department of Public Health, when applying for a permit to construct, that the township board of the township in which the facilities are to be located has given its authorization and approval in all related matters as required by the Constitution, applicable laws and local ordinance.

   2. Submit a statement of its plan for the effective and continuous operation and maintenance of the facilities.

   3. Indicate for what period of time the corporation plans to continue to retain ownership of the facilities under any and all circumstances.

   4. Indicate whether and under what conditions ownership of the facilities may be transferred to or otherwise acquired by the township or other local unit of government.

B. The TOWNSHIP BOARD of the township in which the facilities are to be located shall:

   1. Submit a statement to the Director of the Department of Public Health indicating its willingness and intention to assume responsibility for continuity of effective operation and maintenance of the proposed facilities at any and all times upon failure of the private corporation owning the facilities to do so. Statement to be in form of resolution adopted by Board.

C. The DIRECTOR of the DEPARTMENT OF PUBLIC HEALTH will:

   1. Issue permits for construction only when all information as outlined in A and B above is received.

2. Hold the township fully responsible for the effective operation and maintenance of the approved facilities at any and all times the owner fails to do so.

3. Require the township to make promptly any necessary repairs, replacements, extensions or improvements to such facilities upon failure of the owner to do so as such needs are determined to be required in the public interest.

John E. Vogt

APPROVED:

APPENDIX G

CHLORINATION POLICY

GEORGE ROMNEY, Governor
ALBERT E. HEUSTIS, M.D., Director

STATE OF MICHIGAN
DEPARTMENT OF PUBLIC HEALTH
3500 N. LOGAN, LANSING, MICHIGAN 48914

January 4, 1967

DEPARTMENT LETTER NO. 35-1

TO: Municipalities Operating Sewage Treatment Plants
Bureau Chiefs
Division Chiefs
Directors of Full-Time Local Health Departments

FROM: John E. Vogt, Chief
Division of Engineering

SUBJECT: Disinfection of Sewage Treatment Plant Effluents

For many years most communities and others operating sewage treatment plants have chlorinated their treated wastewaters before discharging them into our streams and lakes. This practice has provided a large measure of protection of the public health. Present trends in public need for higher water quality to permit increased use of our public waters for all forms of aquatic recreation and other uses involving intimate human contact require refinements in present practices for bacteriological control of treated sewage effluents and greater vigilance by those responsible for the operation of the facilities involved. Greater concentrations of people living close to lakes and streams coupled with year-round recreation including fishing in late fall, winter and early spring requires continuous bacteriological control whenever sewage is discharged to the public waters. Seasonal chlorination during the summer recreation season no longer can be depended upon to provide a full measure of protection to the public health.

It therefore is the declared and established policy that:

> All municipalities and others discharging treated sewage from sewage treatment plants to the public waters of the state be required to provide effective bacteriological control over the effluent therefrom by the continuous application each day of the year of chlorine or other effective chemicals in facilities approved by the State Department of Public Health. Effective control requires sufficient testing at approved points of sample collection to assure the maintenance of an adequate residual of chlorine or other disinfecting agents, supplemented by occasional tests for organisms of the coliform group. Adequate disinfection should reduce consistently the concentration of coliform organisms to 1000 or less per 100 ml.

Approved: Albert E. Heustis, M.D.

John E. Vogt.

"Equal Health Opportunity for All"

APPENDIX H

BACTERIOLOGICAL QUALITY
MUNICIPAL WASTE DISCHARGERS
LAKE SUPERIOR BASIN
MICHIGAN PORTION

Table 1

Bacteriological Quality
Municipal Waste Dischargers
Lake Superior Basin
Michigan Portion

Town	Receiving Waters	No. Samples per Month*	MPN per 100 ml Arith. Mean	Median	Test
Houghton-Hancock	Portage Lake	7	7	3.6	MT
Ironwood	Montreal River	6	317	200	MF
Ishpeming	Carp River	7	75	91	MT
Ishpeming Twp. A	Carp River	3	470	430	MT
Isphaming Twp. B	Carp River	3	360	150	MT
L'Anse	Linden Creek to Keweenaw Bay	11	6150	12	MT
Marquette	Carp River	15	1100	1500	MT
Munising	Anna River	7	250	92	MT
Ontonagon	Ontonagon River	4	18	19	MT
White Pine	Mineral River	8	18	1.5	MT

*Nearly all data is from month of September 1968.

APPENDIX I

INDUSTRIAL SURFACE WATER DISCHARGES
IN
THE LAKE SUPERIOR BASIN

TABLE I

MICHIGAN'S
DIRECT INDUSTRIAL DISCHARGES TO LAKE SUPERIOR

Company Name	Product	Location	Treatment	Discharge Characteristics after Treatment			1969 Pollution Status Rating	Date of Order of Determination	Remarks
				Flow MGD	5-day BOD lbs/day	Suspended Solids lbs/day			
Royal Oak Charcoal	Charcoal briquettes	Marquette	Oil and tar separators Sanitary to city sewers	5.1	4,116	333	B	None	---
Kimberly Clark Corp.	Paper products	Munising	Chemical precipitation and settling Sanitary to city sewers	5.33	---	650	B	None	---
Marquette Board of Power and Light	Electricity	Marquette	Cooling water-none Ash disposal-lagoon	- No data available -			A A	Sept. 1967	---
U.P. Generating Co.	Electricity	Marquette	Cooling water-none Ash disposal-lagoon	- No data available - - No data available -			A A	July 1965	---

TABLE 2

MICHIGAN'S INDUSTRIAL SURFACE WATER DISCHARGES LAKE SUPERIOR BASIN

Company Name	Product	Location	Receiving Stream	Treatment Provided	Discharge Characteristics after Treatment: Flow MGD	5-day BOD lbs/day	Suspended Solids lbs/day	1959 Pollution Status Rating	Date of Order of Determination	Remarks
1. Montreal River Basin										
Superior Packing Company	Meat	Ironwood	Ground water	Septic tank and tile field		- - - - No data available - - - -		B	None	---
William E. Hoki Slaughterhouse	Meat	Ironwood	Ground water	Septic tank and dry well		- - - - No data available - - - -		B	None	---
2. Black River Basin										
Anderson's Grocery Slaughterhouse	Meat	Ironwood	Ground water	Septic tank		- - - - No data available - - - -		B	None	---
3. Presque Isle River Basin										
- - - - No major industries in basin - - - -										
4. Mineral River Basin										
White Pine Copper Co.	Copper	White Pine	Nation Creek and Mineral River	Chemical precipitation and settling	21.6			A	July 1958	---
White Pine Copper Co. Tolfrey Shaft	Copper ore	White Pine	Tolfrey and Argentine Creeks	Secondary treatment for san. sewage				B	Oct. 1958	---
5. Ontonagon River Basin										
Hoerner-Waldorf, Inc. Ontonagon Mill Division	Paper	Ontonagon	Ontonagon River	Save-all Sanitary to city sewer	5.5	13,000	4,500	C	None	Taste and Odor Problem
Ontonagon Valley Co-op Creamery	Milk and cheese	Bruce Crossing	Clear Creek	Haul whey away		- - - - No data available - - - -		B	None	---
The Nordine Laundromat		Bruce Crossing	Ground water	Lagoon		- - - - No data available - - - -		A		---
6. [illegible] River Basin										
Lake Superior Engineering Inc.		Winona	Ground water	None		- - - - No data available - - - -		B	March 1957	---
7. Portage River Basin										
Bosch Brewing Co.	Beer	Houghton	Portage Lake	Settling screens Sanitary-septic tank and tile field	---	595	---	B	None	---
Calumet & Hecla, Inc. (Ahmeek Mill)	Copper concentrate	Hubbell	Torch Lake	None		4,000 tons tailings per day		B	None	---
Calumet & Hecla, Inc. (Osceola #13 mine)	Copper ore	Calumet	Hammell Creek and Torch Lake	None	3.5			B	June 1959	---
8. Sturgeon River Basin										
- - - - No major industries in basin - - - -										
9. Falls River Basin										
Celotex Corporation	Building board	L'Anse	Ground water	Lagoon and spray irrigation	0.400	---	---	A	Sept. 1956	---
U.P. Power Company	Electricity	L'Anse	Falls River	Cooling water-none	---	---	---	A	Aug. 1958	---
				Ash disposal-none	---	---	---	A		---
10. Dead River Basin										
Marquette Board of Power and Light Diesel Plant	Electricity	Marquette	Dead River	None		- - - - No data available - - - -		C	None	Minor oil problem
Bancroft Dairy	Milk and dairy products	Marquette	Creek and Dead River	Septic tank	.050	---	---	C	None	---

Company Name	Product	Location	Receiving Stream	Treatment Provided	Discharge Characteristics After Treatment: Flow MGD	5-day BOD lbs/day	Suspended Solids lbs/day	1969 Pollution Status Rating	Date of Order or Determination	Remarks
11. **Carp River Basin**										
Cleveland Cliffs Iron Company (Ore Improvement Plant)	Iron ore	Negaunee	Ground water	Settling ponds	[illegible]	---	---	A	May 1967	---
Cleveland Cliffs Iron Company (Pioneer Pellet Plant)	Iron ore pellets	Negaunee	Ground water	Settling ponds	---	---	---	A	See Order	---
Cleveland Cliffs Iron Company (Eagle Mills Pellet Plant)	Iron ore pellets	Negaunee	Ground water	Settling ponds	---	---	---	A	See Order	---
Northern Automatic Electric Foundry	Iron castings	Ishpeming	Ground water and Carp River	Settling and cooling ponds	- - - - No data available - - - -			B	Oct. 1968	---
12. **Chocolay River Basin**										
James Siewert Laundromat		Harvey	Ground water	Lagoon	- - - - No data available - - - -			B	None	---
13. **Au Train River Basin**										
- - - - - - - - - - - - - - - - No major industries in basin - - - - - - - - - - - - - - - -										
14. **Two Hearted River Basin**										
- - - - - - - - - - - - - - - - No major industries in basin - - - - - - - - - - - - - - - -										
15. **Tahquamenon Basin**										
Sones' Slaughterhouse	Meat	Newberry	Ground water	None	- - - - No data available - - - -			B	None	---
16. **Waiska River Basin**										
- - - - - - - - - - - - - - - - No major industries in basin - - - - - - - - - - - - - - - -										
Industries with Discharges in Mine Drainage Areas										
Calumet & Hecla, Inc. (Centennial #3 Mine)	Copper ore	Calumet	Hill Creek	Underground settling	- - - - No data available - - - -			B	None	---
Calumet & Hecla, Inc. (Centennial #6 Mine)	Copper ore	Calumet	Hill Creek	Underground settling	- - - - No data available - - - -			B	None	---
Calumet & Hecla, Inc. (Allouez #3 Mine)	Copper ore	Ahmeek	Hill Creek	Underground settling	- - - - No data available - - - -			B	None	---
Calumet & Hecla, Inc. (Kingston Mine)	Copper ore	Ahmeek	Hill Creek	Underground settling	- - - - No data available - - - -			B	None	---

APPENDIX J

MUNICIPAL SURFACE WATER DISCHARGES
IN
THE LAKE SUPERIOR BASIN

TABLE I

MICHIGAN'S
MUNICIPAL SURFACE WATER DISCHARGES
LAKE SUPERIOR BASIN

				Discharge Characteristics							
Community	Receiving Waters	Treatment Provided	Population (1966 est.)	5-day BOD Influent mg/l	5-day BOD Effluent mg/l	5-day BOD Effluent % Removal	Suspended Solids Influent mg/l	Suspended Solids Effluent mg/l	Suspended Solids Effluent % Removal	Flow MGD	Status and Abatement Action
Discharge Directly to Lake Superior											
Baraga	Lake Superior	Primary ST	900	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Montreal River Basin											
Erwin Twp.	Ground Waters	Secondary ST	100	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK
Ironwood	Montreal River	Secondary AS	10,260	79	7	90	93	4	96	1.54	Current facilities satisfactory
Ironwood Township	Welch Creek	Secondary TF	420	250	66	74	146	46	69	0.02	Current facilities satisfactory
Black River Basin											
Bessemer	Kallander Creek	Secondary TF	3,300	155	22	86	97	10	90	0.47	Engineers employed
Ramsay	Black River	None	1,100	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Engineers employed
Wakefield	Planter Creek	Secondary L	3,230	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		New Plant. Operating satisfactorily
Presque Isle River											
Marenisco	Presque Isle River	None	900	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Engineers employed. Conference held September 29, 1966, corrective program underway
Mineral River Basin											
White Pine	Mineral River	Secondary TF	900	79	17	78	111	17	85	0.32	Current facilities satisfactory
Ontonagon River Basin											
Bergland	Lake Gogebic	None	600	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Bruce Crossing	Clear Creek	None	100	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Ewen	S. Branch Ontonagon R.	None	900	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Ontonagon	Ontonagon River	Primary	2,350	100	65	35	80	42	47	0.20	Current facilities satisfactory
Rockland	Rockland Creek	None	570	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Watersmeet	Middle Branch Ontonagon River	Primary ST	500	200	90	55	80	40	50	0.05	Current facilities satisfactory
Sturgeon River Basin											
Mass-Greenland	Flintsteel River	None	500	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Pre-engineering report received
Portage Lake Basin											
Baltic	Branch Pilgrim R.	Primary ST	100	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK
Copper City	Trap Rock River	Primary ST	200	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK
Florida	Hammell Creek	None	400	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Served by Laurium
Laurium	Hammell Creek	Primary ST	3,000	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		Plans approved
Painesdale[1]	Ditches	None	950	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK
South Range	Branch Pilgrim R.	Primary ST	750	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK
Portage Township	Huron Creek	None	50	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -		OK

[1] Small amount discharged to Otter River - Sturgeon Basin.

Community	Receiving Waters	Treatment Provided	Population (1960 est.)	5-day BOD Influent mg/l	5-day BOD Effluent mg/l	5-day BOD Effluent % Removal	Suspended Solids Influent mg/l	Suspended Solids Effluent mg/l	Suspended Solids Effluent % Removal	Flow MGD	Status and Abatement Action
Carp River Basin											
Ishpeming	Carp River	Primary	7,000	82	33	58	96	30	67	1.15	Current facilities satisfactory
Ishpeming Twp. #	Carp River	Primary TF	1,000	166	105	37	153	67	55	0.09	Current facilities satisfactory
Ishpeming Twp. #	Carp River	Primary TF	900	215	131	39	230	93	60	0.02	Current facilities satisfactory
Marquette	Carp River	Primary	21,000	116	57	50	117	51	92	2.64	Current facilities satisfactory
Negaunee	Ditch	Secondary TF	6,000	105	21	80	97	55	70	0.27	Current facilities satisfactory
Au Train River Basin											
Chatham	Slapneck Creek	None	300	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Engineers employed. Conference held September 30, 1966, corrective program underway
Tahquamenon River Basin											
Newberry	Tahquamenon River	Primary	2,075	167	110	34	171	81	53	0.75	Current facilities satisfactory
Miscellaneous											
Ahmeek	Hills Creek	None	355	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Pre-engineering report received.
Allouez	Hills Creek	None	175	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Conference held September 30, 1966, corrective program underway
Big Bay	Lake Independence	Primary ST	275	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	6a
Calumet	Ground waters	Secondary SL	1,140	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Served by Northern Michigan Water Co.
Gay	Tobacco River	Primary ST	150	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	6a
Houghton-Hancock	Portage Lake	Secondary AS	12,400	122	10	90	170	17	90	1.81	Served by Portage Lake Water and Sewage Authority
Hubbell	Torch Lake	None	1,400	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Engineers employed
Lake Linden	Torch Lake	None	1,300	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Engineers employed Conference held September 30, 1966, corrective program underway
L'Anse	Linden Creek	Secondary AS	2,200	111	5	96	116	3	96	0.20	Current facilities satisfactory
Mohawk	Hills Creek	None	372	- - - - - - - -	- - - - - - - -	No Data Available	- - - - - - - -	- - - - - - - -	- - - - - - - -	- - - -	Pre-engineering report received
Munising	Anna River	Primary	4,100	102	53	48	68	23	52	1.03	Current facilities satisfactory

NOTE:
A.S. - Activated Sludge
T.F. - Trickling Filter
S.F. - Sand Filter
L. - Lagoons
S.L. - Seepage Lagoons
I.T. - Imhoff Tank
S.T. - Septic Tank
6a - Units have been notified that they are in violation of Section 6a, Act 245; voluntary corrective action being sought.

APPENDIX K

FEDERAL SURFACE WATER DISCHARGES
IN
THE LAKE SUPERIOR BASIN

TABLE I

MICHIGAN'S
FEDERAL INSTALLATION WASTE WATER DISCHARGES
LAKE SUPERIOR BASIN

	Federal Installation	Location	Receiving Stream	Treatment Provided	Population*	Flow gpd
1.	**Montreal River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
2.	**Black River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
3.	**Presque Isle River Basin**					
	National Forest Service Ojibway Job Corp Center	Marenisco	Wellington Creek	Secondary	250	15,000 (Sanitary)
4.	**Mineral River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
5.	**Ontonagon River Basin**					
	U.S. Corps of Engineers (former Light Station)	Ontonagon	Lake Superior	None	1-50	280 (Sanitary)
	National Forest Service Kenton Ranger Station	Houghton County	Ontonagon River	Secondary	1-50	800 (Sanitary)
6.	**Sleeping River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
7.	**Portage River Basin**					
	U.S. Air Force - Calumet Air Force Station	Ahmeek	Central Creek	Secondary	---	32,000 (Sanitary)
	U.S. Coast Guard Keweenaw Lower Entrance to Lake Superior	Houghton County	Lake Superior	Secondary	1-50	1,100 (Sanitary)
8.	**Sturgeon River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
9.	**Falls River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
10.	**Dead River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
11.	**Carp River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			

	Federal Installation	Location	Receiving Stream	Treatment Provided	Population	Flow gpd
12.	**Chocolay River Basin** U.S. Air Force K.I. Sawyer Air Force Base	Republic	Silver Lead Creek	Secondary (Presently expanding & improving secondary facilities)	----	668,000 (Sanitary)
13.	**Au Train River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
14.	**Two Hearted River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
15.	**Tahquamenon River Basin**		- - - - - - - - No major discharges to surface waters - - - - - - - -			
16.	**Waiska River Basin** U.S. Air Force Kincheloe Air Force Base	Kinross	Swamp	Secondary	----	254,000 (Sanitary)
	Miscellaneous Drainage Areas					
	U.S. Coast Guard Stannard Rock Light Station	Keweenaw Co.	Lake Superior	None	1-50	280 (Sanitary)
	U.S. Coast Guard Light Station	Eagle Harbor	Lake Superior	Secondary	1-50	700 (Sanitary)
	U.S. Coast Guard Huron Island Light Station	Marquette County	Lake Superior	Secondary	1-50	500 (Sanitary)
	U.S. Coast Guard Passage Island Light Station	Keweenaw County	Lake Superior	Primary	1-50	500 (Sanitary)
	U.S. Coast Guard Rock of Ages Light Station	Keweenaw County	Lake Superior	None	1-50	500 (Sanitary)

* Department of Defense population figures are not published.

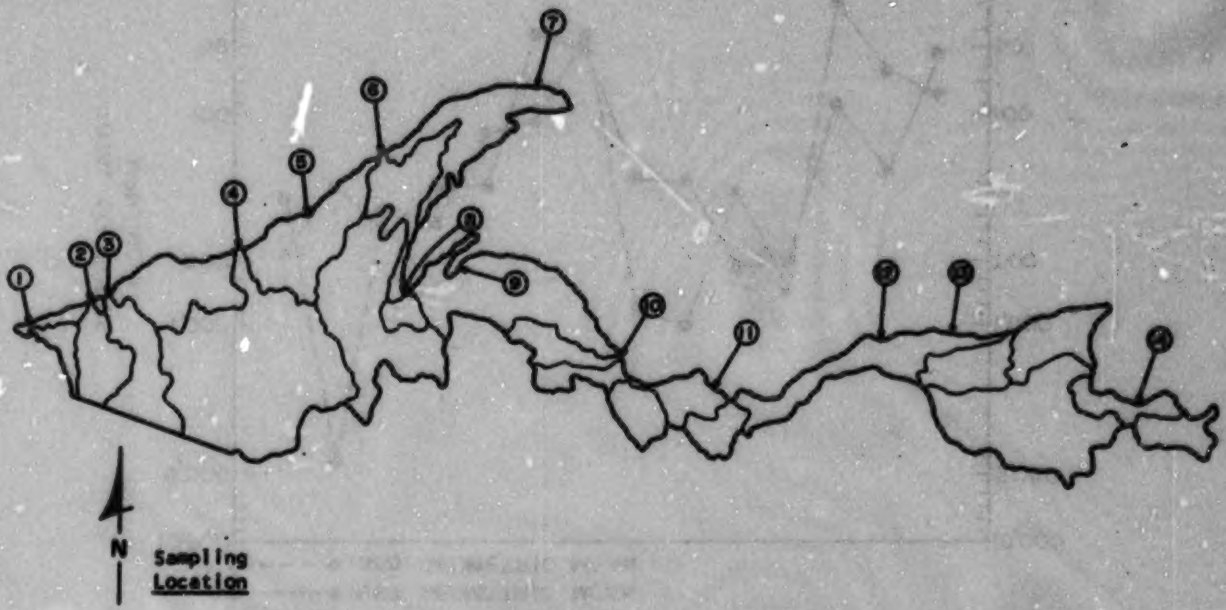
APPENDIX L

BACTERIOLOGICAL DATA FOR LAKE SUPERIOR WATERS ALONG MICHIGAN'S COASTLINE

MAP I

LAKE SUPERIOR

BEACH SAMPLING LOCATIONS



Sampling Location

1. Little Girls Pt. Park
2. Black River Park
3. Porcupine Mts. State Park
4. Ontonagon Twp. Park
5. Stanford Twp. Park
6. MClain State Park
7. Ft. Wilkins State Park
8. Barage State Park
9. Arvon Twp. Park
10. Marquette
11. Munising
12. Grand Marais
13. Lake Superior Camp Grounds
14. Bay View

FIGURE I

BACTERIOLOGICAL DATA
FOR
LAKE SUPERIOR WATERS
ALONG
MICHIGAN'S COASTLINE
1967 & 1968

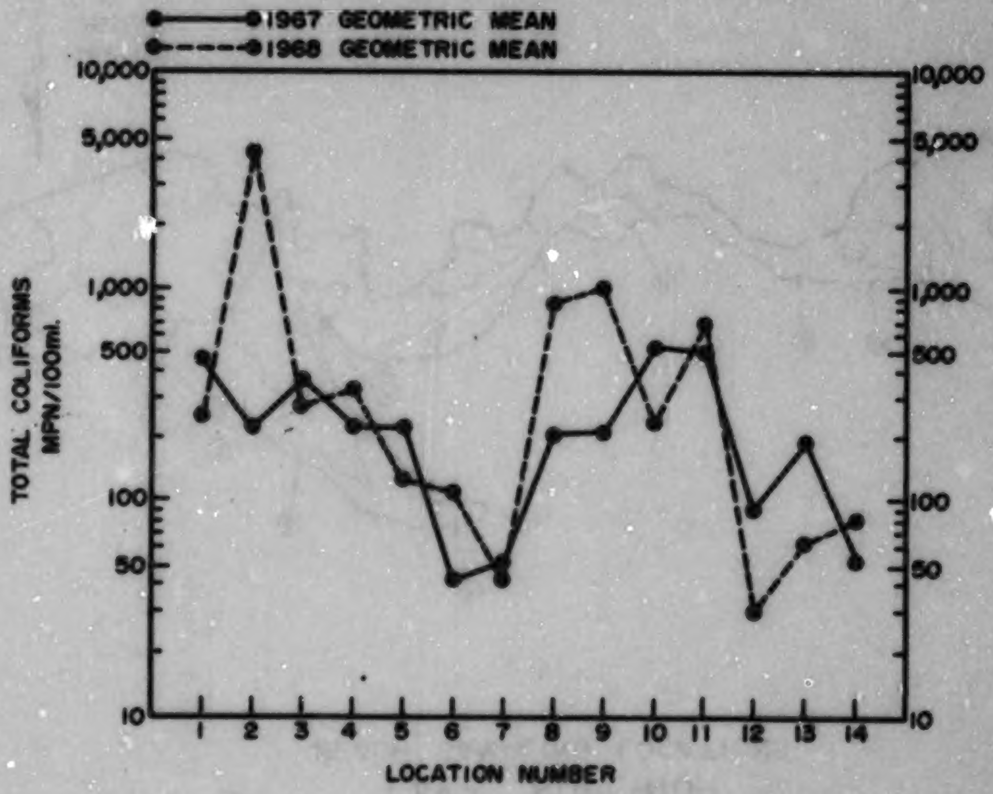


TABLE 1

SUMMARY OF BACTERIOLOGICAL DATA FOR LAKE SUPERIOR WATERS ALONG MICHIGAN'S UPPER PENINSULA COASTLINE

Sampling Location	1967 Results Min.	Max.	Geo. Mean	No. of Samples	1968 Results Min.	Max.	Geo. Mean	No. of Samples
1. Little Girls Pt. Park	230	930	462	2	36	1,500	246	4
2. Black River Park	230	230	230	2	1,500	24,000	4,337	4
3. Porcupine Mts. State Park	230	930	385	5	36	2,300	287	8
4. Ontonagon Twp. Park	230	230	230	2	<30	2,300	313	4
5. Stanford Twp. Park	230	230	230	2	<30	430	130	4
6. McLain State Park	<30	230	41	7	<30	1,500	110	8
7. Ft. Wilkins State Park	<30	210	52	6	<30	930	42	12
8. Baraga State Park	<30	930	206	4	230	2,300	822	4
9. Arvon Twp. Park	<30	1,500	212	2	430	2,300	994	2
10. Marquette	<30	9,300	527	2	73	2,300	237	8
11. Munising	<30	91	519	2	<30	24,000	684	8
12. Grand Marais	91	91	91	1	<30	<30	30	3
13. Lake Superior Camp Grounds	91	430	198	2	<30	360	63	6
14. Bay View	<30	91	53	2	<30	750	80	8

Note: Results expressed as MPN per 100 ml.

APPENDIX M

RADIOACTIVITY SAMPLE RESULTS

TABLE I

RADIOACTIVITY SAMPLE RESULTS

WATER INTAKE

MARQUETTE, MICHIGAN

MICROMICROCURIES / LITER

Year	January		February		March		April		May		June		July		August		September		October		November		December	
	Act.	% ±*	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±	Act.	% ±
1959	0	--	2	80	0	--			0	--	0	--	0	--	0	--	0	--			6	140	5	35
1960	0	--	0	--	3	53	4	45			3	60	0	--			0	--	0	--	0	--	0	--
1961	0	--	0	--	0	--	0	--	0	--	0	--	0	--	0	--	4	53	6	28	4	53	7	23
1962	4	53	4	53	0	--	3	53	0	--	11	16	0	--	0	--	5	37	19	10	0	--	0	--
1963	0	--	6	28	4	53	0	--	7	28	15	12	10	19	8	23			4	53	0	--	0	--
1964	2	105	4	53	<1	--					<1	--	<1	--	8	28	4	53	<1	--	<1	--	6	28
1965	6	37	<1	--	6	37	<1	--	<1	--	<1	--	<1	--			<1	--			<1	--	<1	--
1966	10	23	<1	--	6	37	3	37	<1	--							<1	--	<1	--	4	53	<1	--
1967	4	53			<1	--	<1	--	<1	--	4	53									<1	--		
1968	<1	--			<1	--	<1	--																

* Probable error

APPENDIX N

WATER QUALITY MONITORING PROGRAM

TABLE 1

TRIBUTARY WATER QUALITY STATION DESCRIPTION

Station No.	River	Location
1	Montreal near Saxon	County Road 505 bridge
2	Black River below Rainbow Falls	North end of County Road 513
3	Presque Isle River above Nawadaha Falls	Bridge on County Road prior to Nawadaha Falls
4	Ontonagon River in Ontonagon	Bridge on M-64
5	Portage Lake Ship Canal below Oskar	U.S. Coast Guard Station on M-203
6	Sturgeon River near Chassell	Bridge on M-41
7	Hills Creek below Ahmeek	Mouth at Lake Superior
8	Carp River near Marquette	Bridge on U.S. 41
9	Tahquamenon River near Paradise	Bridge on M-123

MAP I

STATE OF MICHIGAN
MICHIGAN PORTION
LAKE SUPERIOR DRAINAGE BASIN
STATIONS IN WATER QUALITY MONITORING PROGRAM

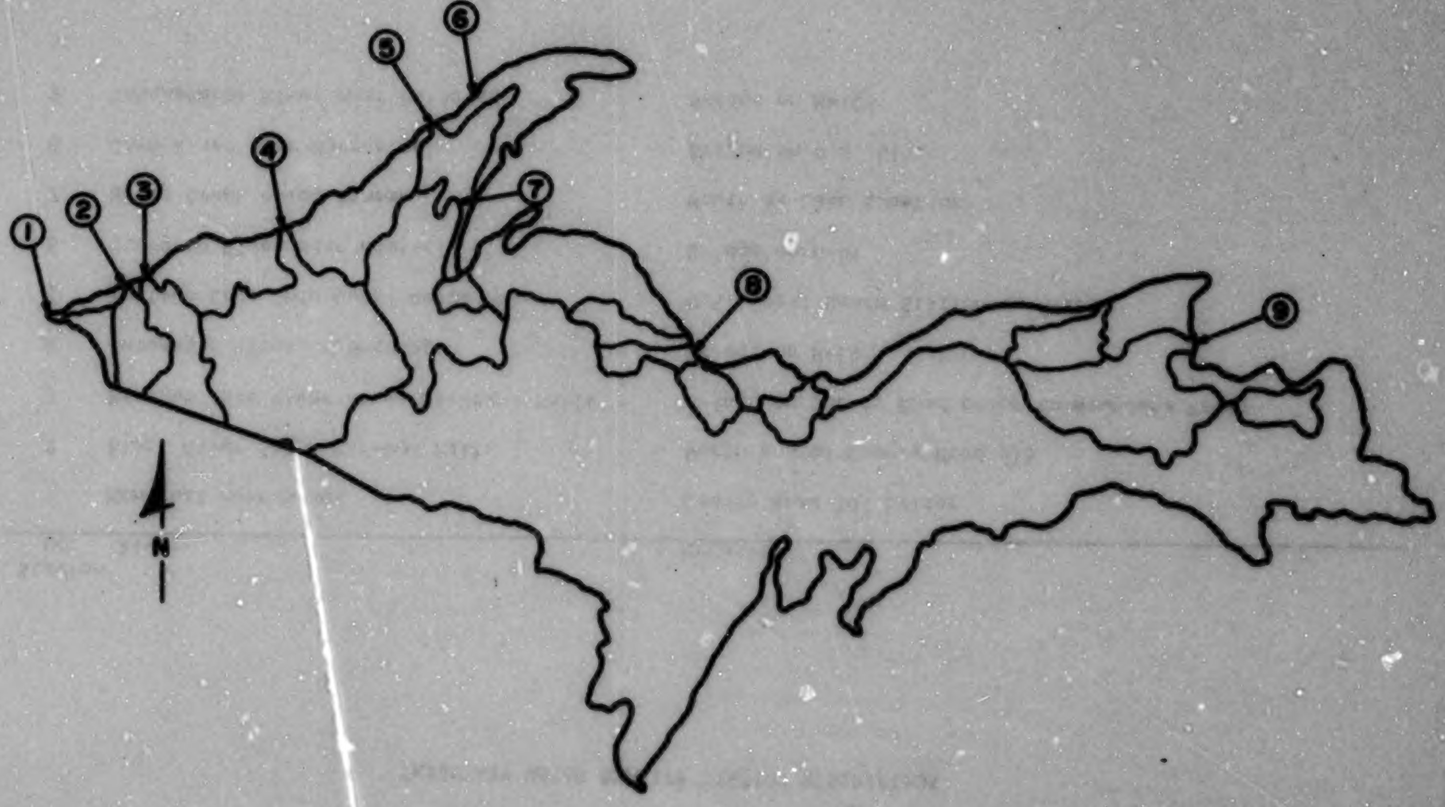


FIGURE I

SELECTED WATER QUALITY PARAMETERS

MONTREAL RIVER
1967—1968—1969

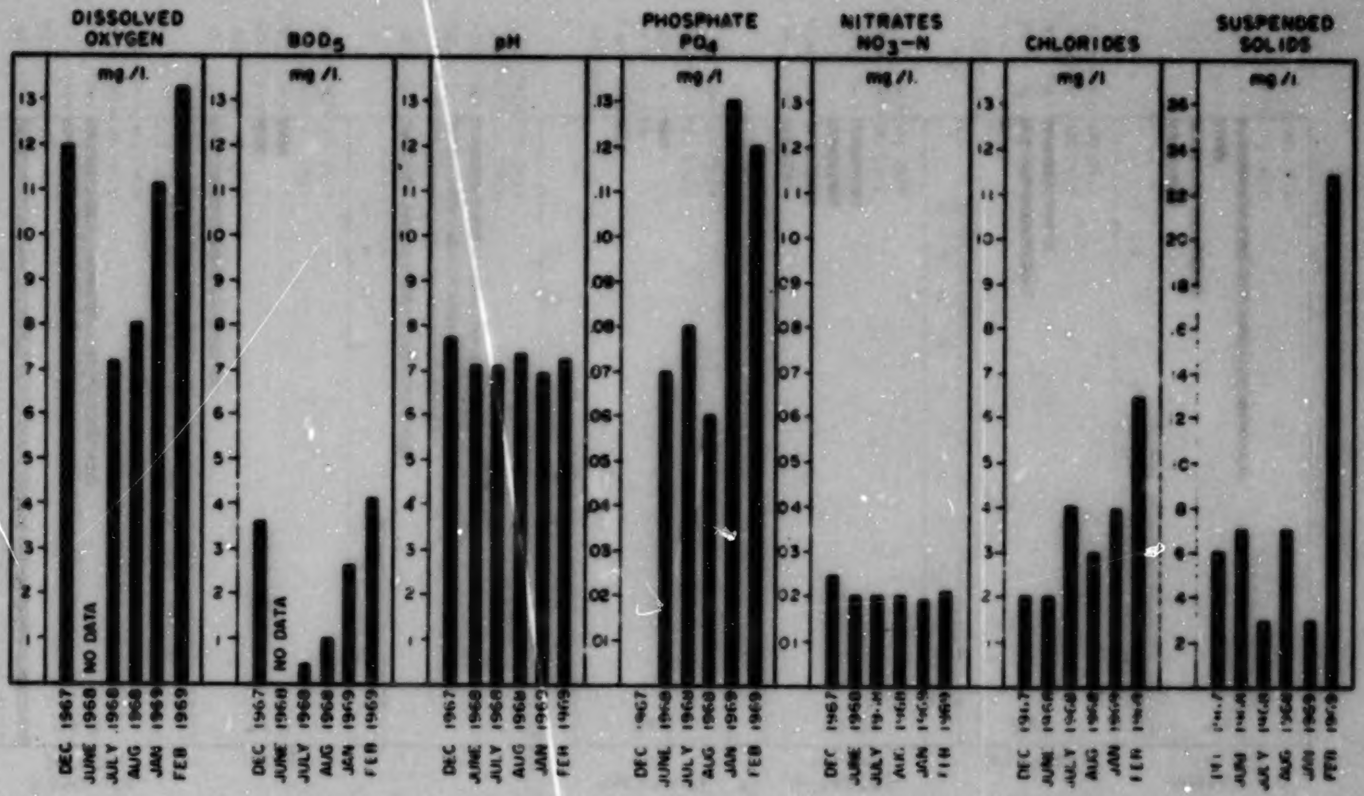


FIGURE 2

SELECTED WATER QUALITY PARAMETERS

BLACK RIVER

1967—1968—1969

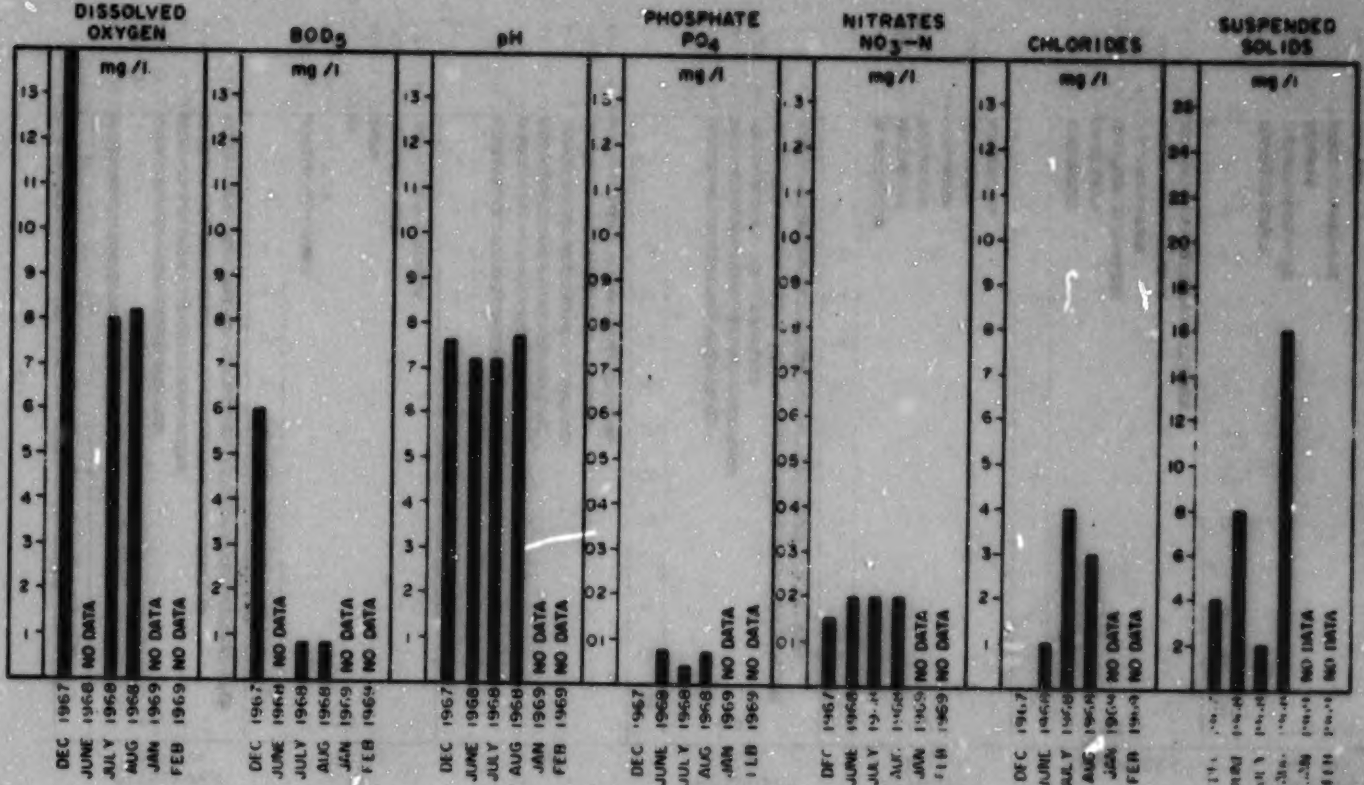


FIGURE 3

SELECTED WATER QUALITY PARAMETERS

PRESQUE ISLE RIVER
1967—1968—1969

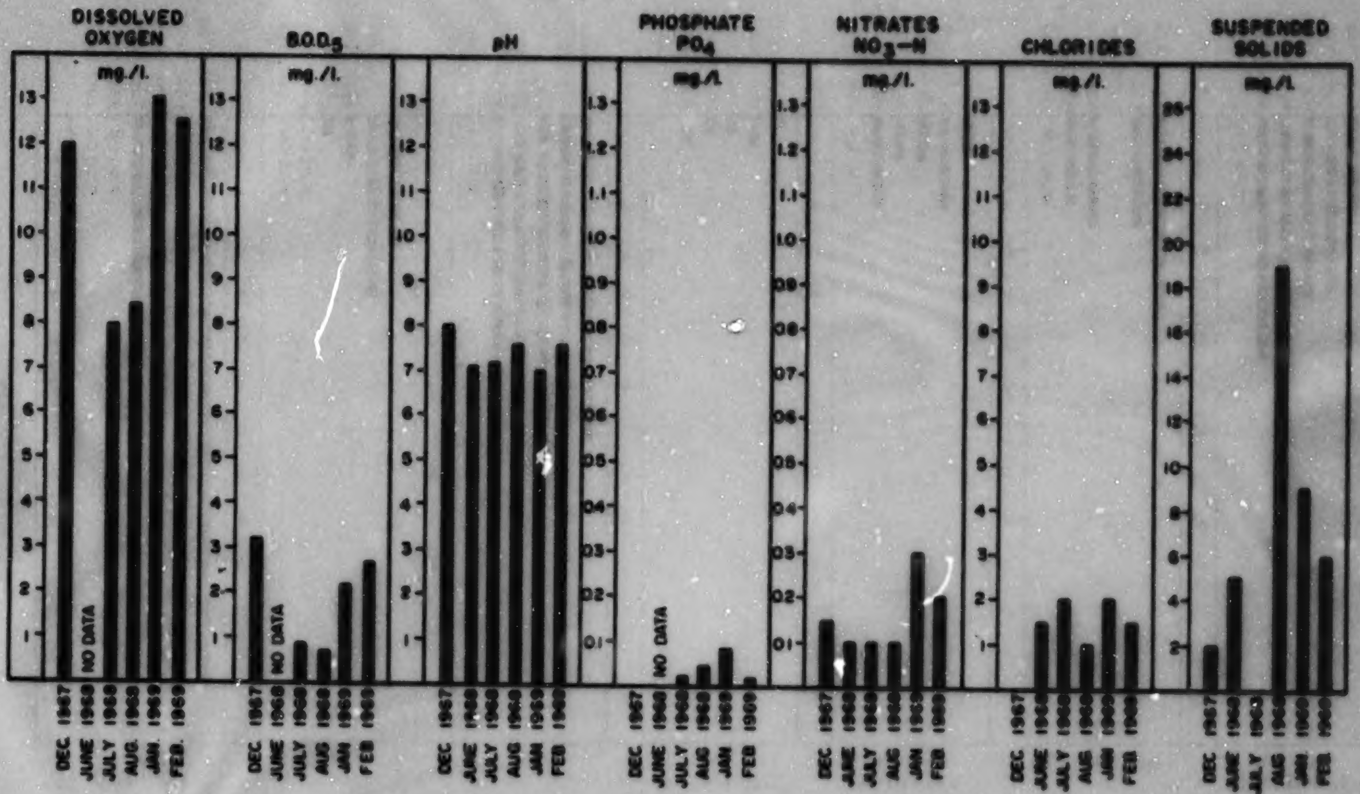


FIGURE 4

SELECTED WATER QUALITY PARAMETERS

ONTONAGON RIVER

1967 – 1968 – 1969

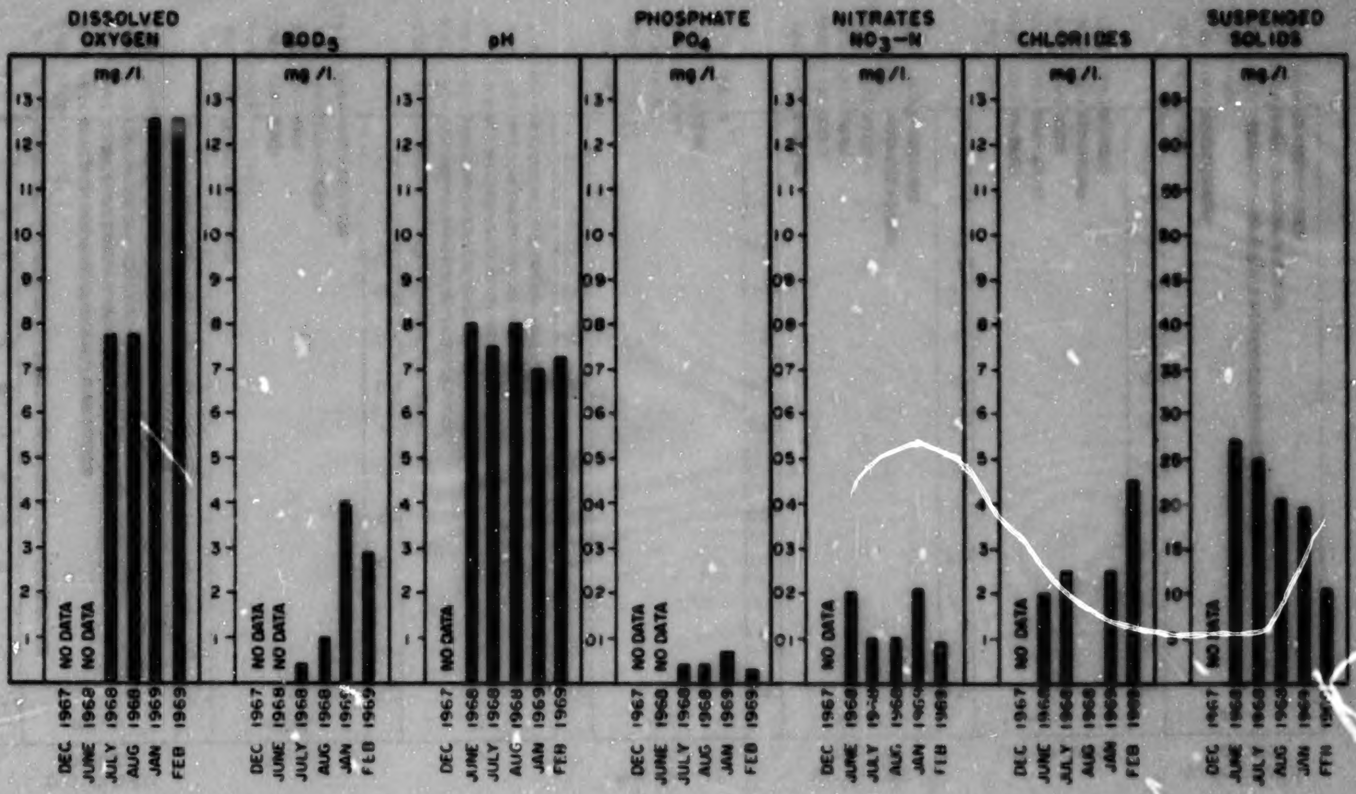


FIGURE 5

SELECTED WATER QUALITY PARAMETERS

PORTAGE LAKE SHIP CANAL

1967—1968—1969

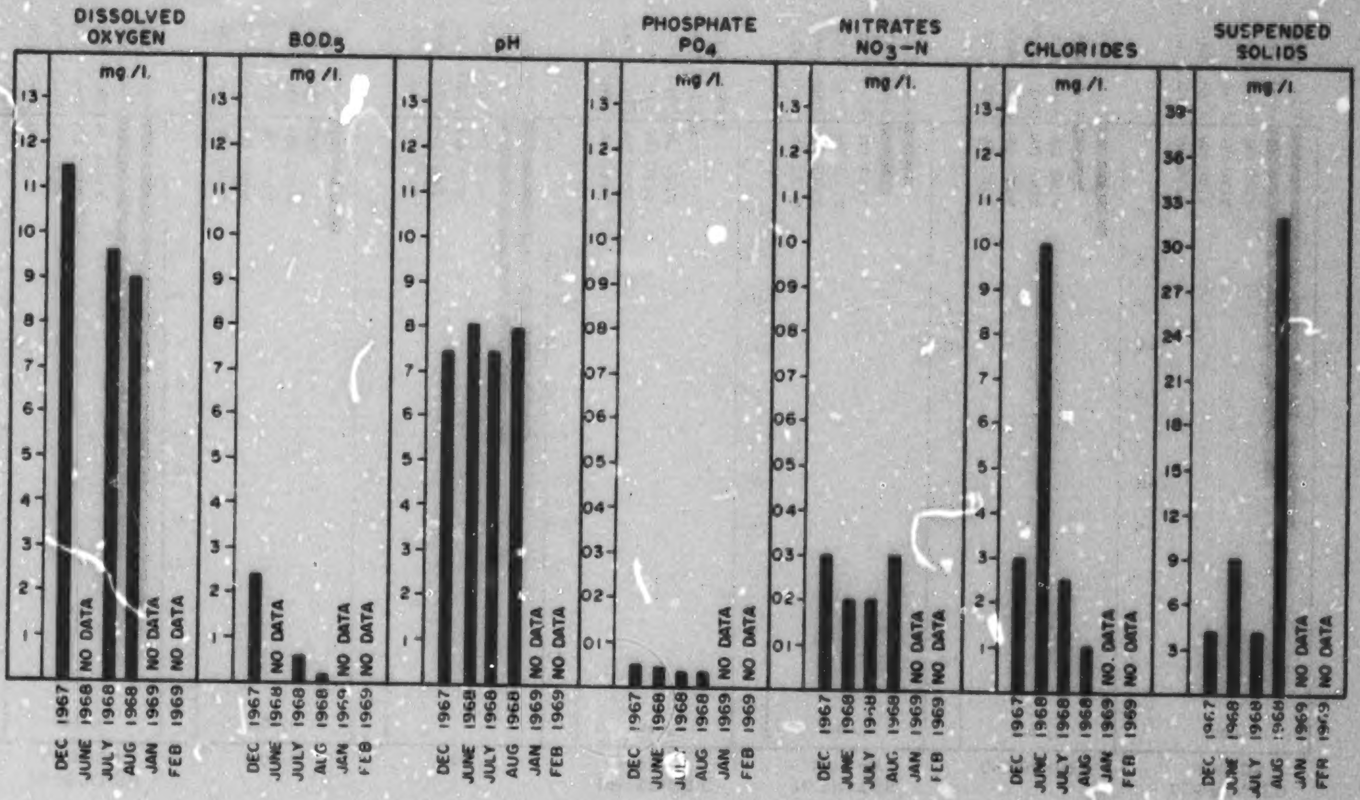


FIGURE 6
SELECTED WATER QUALITY PARAMETERS
STURGEON RIVER
1967 — 1968 — 1969

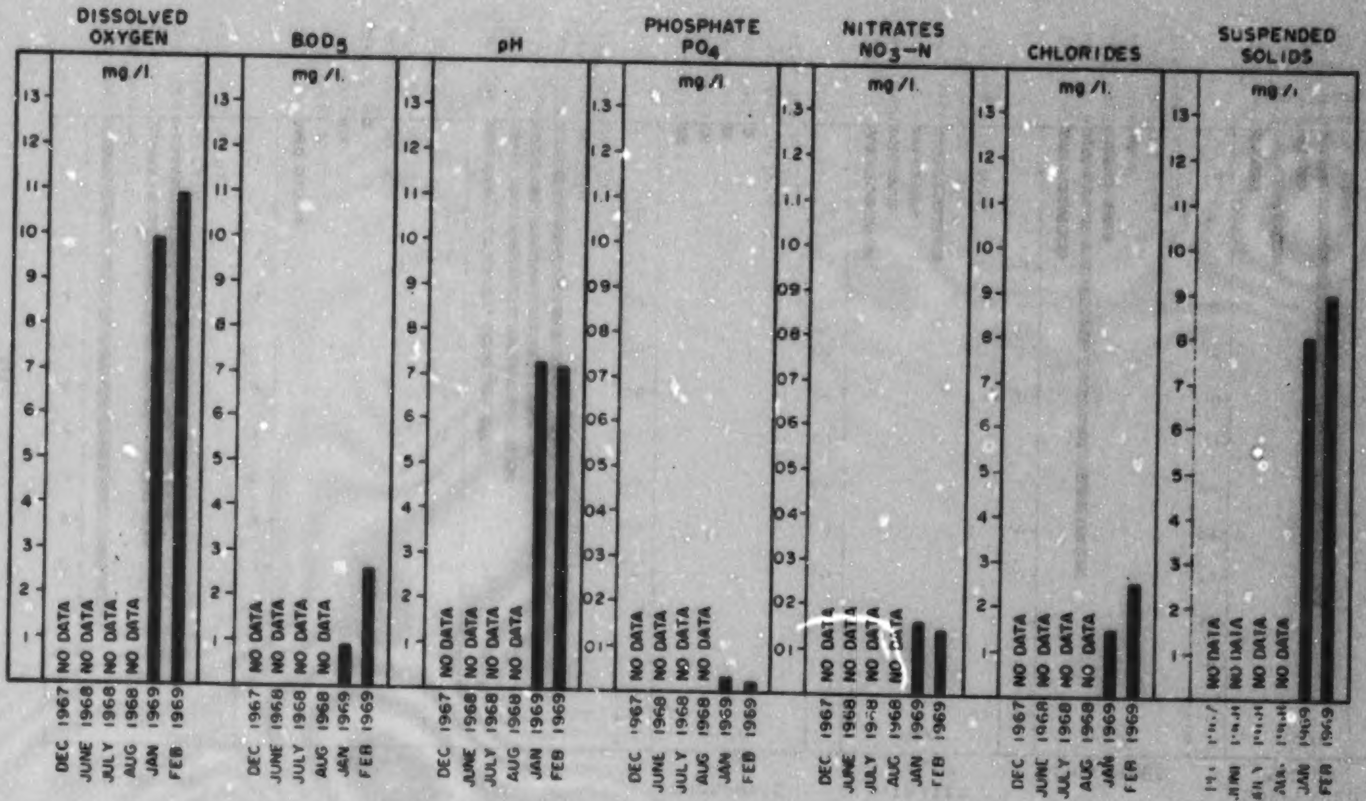


FIGURE 7

SELECTED WATER QUALITY PARAMETERS

HILLS CREEK

1967—1968—1969

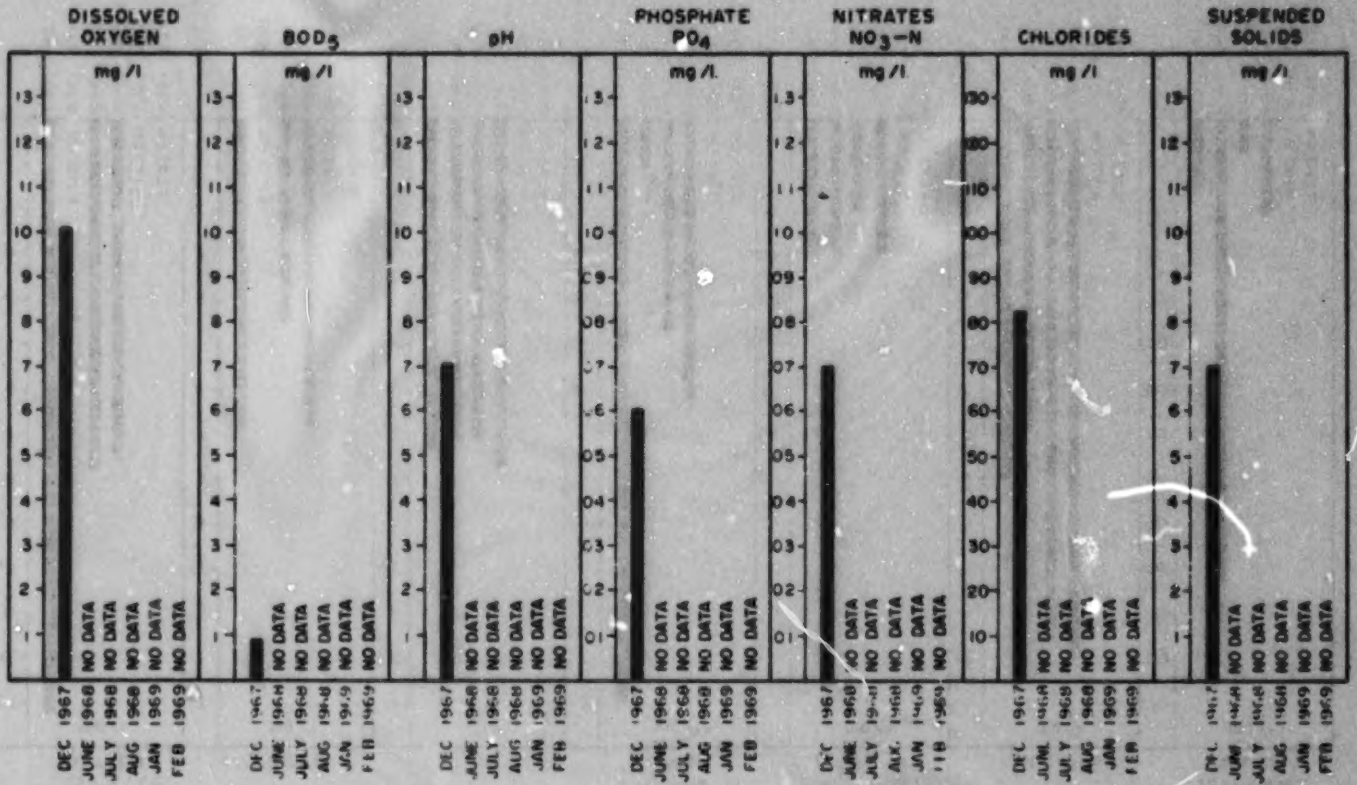


FIGURE 8

SELECTED WATER QUALITY PARAMETERS

CARP RIVER

1967—1968—1969

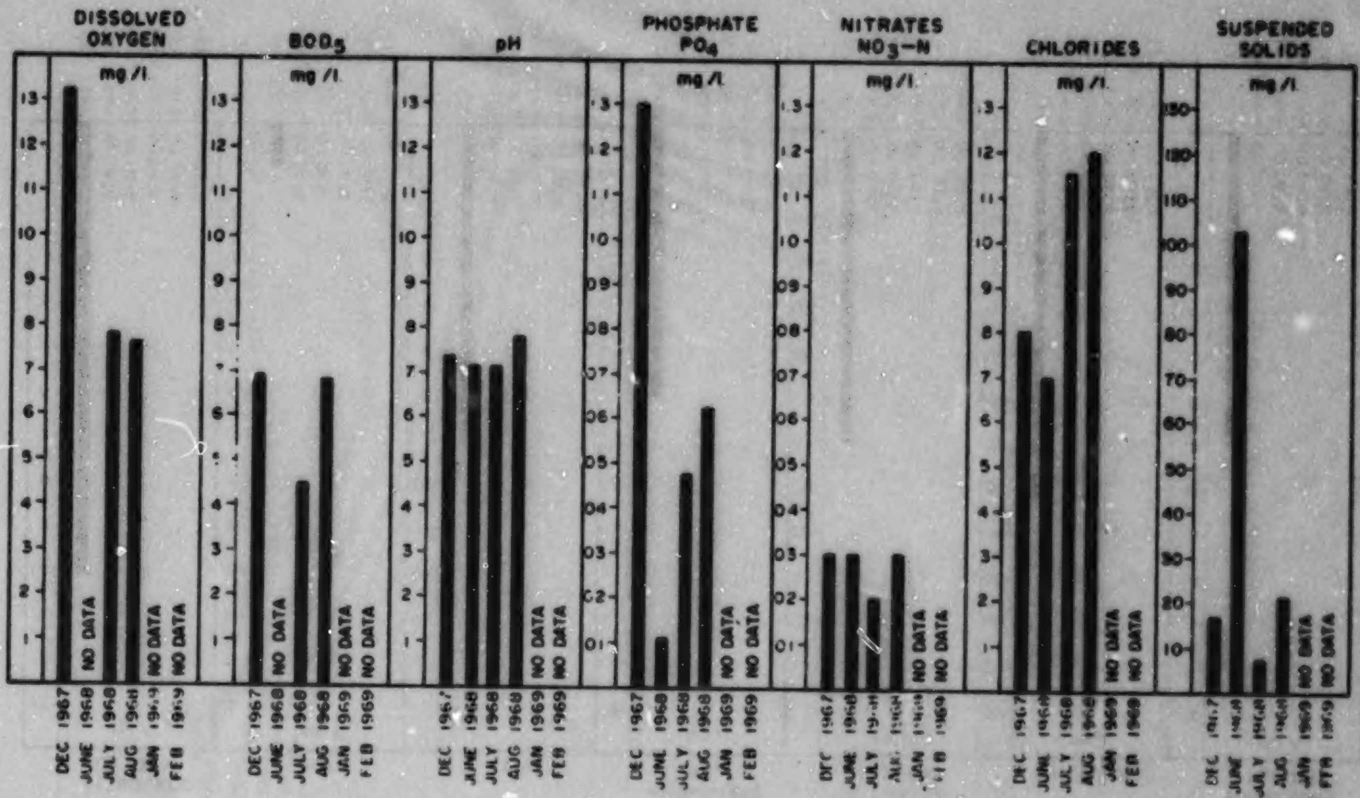


FIGURE 9

SELECTED WATER QUALITY PARAMETERS

TAHQUAMENON RIVER
1967—1968—1969

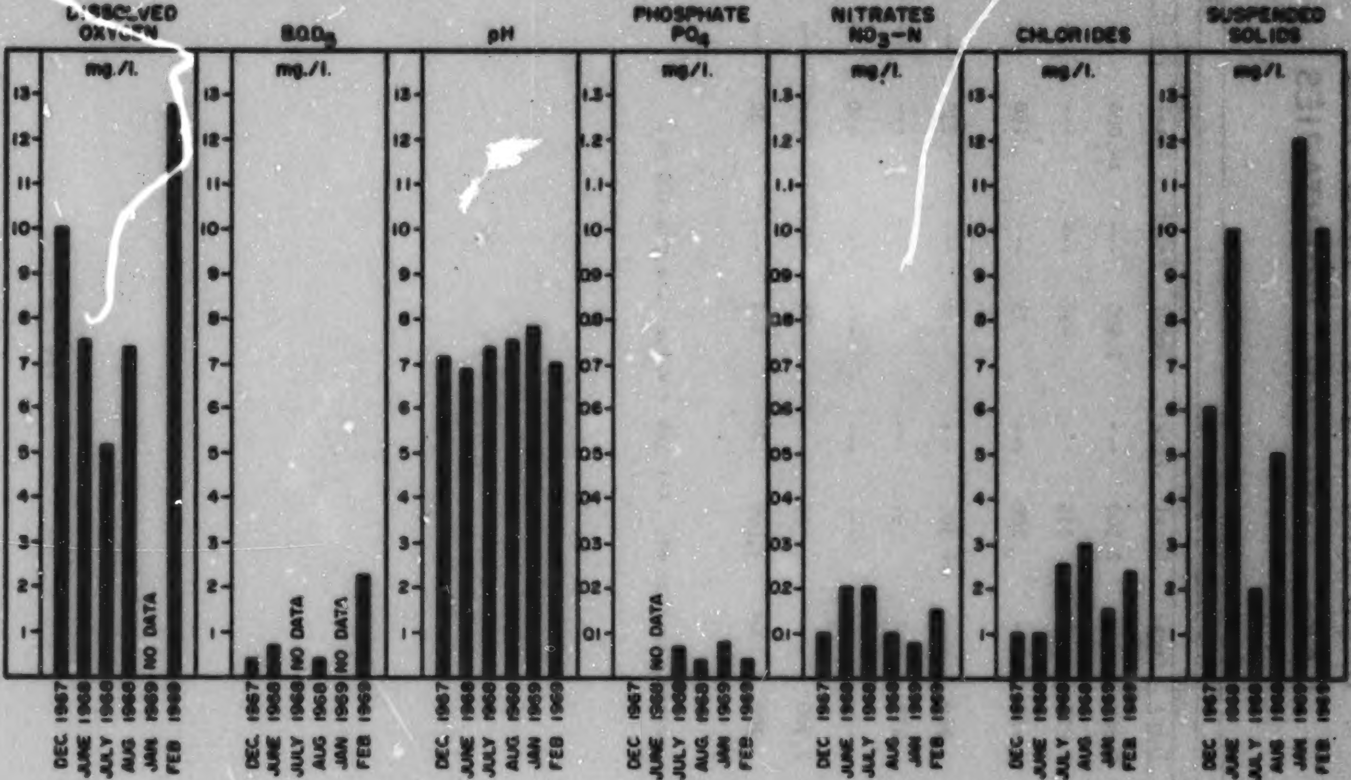


TABLE 2

WATER QUALITY MONITORING PROGRAM

COLIFORM COUNTS 1968-1969

LAKE SUPERIOR TRIBUTARIES

Station No.	1968						1969			
	June		July		August		January		February	
	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal	Total	Fecal
1. Montreal	9,300	---	2,300	---	7,500	---	24,000	---	11,000	100
2. Black	3,900	---	930	---	430	---	---	---	---	---
3. Presque Isle	2,100	---	200	---	73	---	150	---	100	100
4. Ontonagon	930	---	4,300	---	930	---	230	---	35,000	100
5. Portage	210	---	91	---	30	---	---	---	---	---
6. Sturgeon	---	---	---	---	---	---	430	---	1,300	100
8. Carp	2,300	---	30	---	91	---	---	---	---	---
9. Tahquamenon	700*	100*	1,500	20	230	---	30	---	930	---

*Membrane filter method, org/100 ml. All other values are MPN/100 ml.

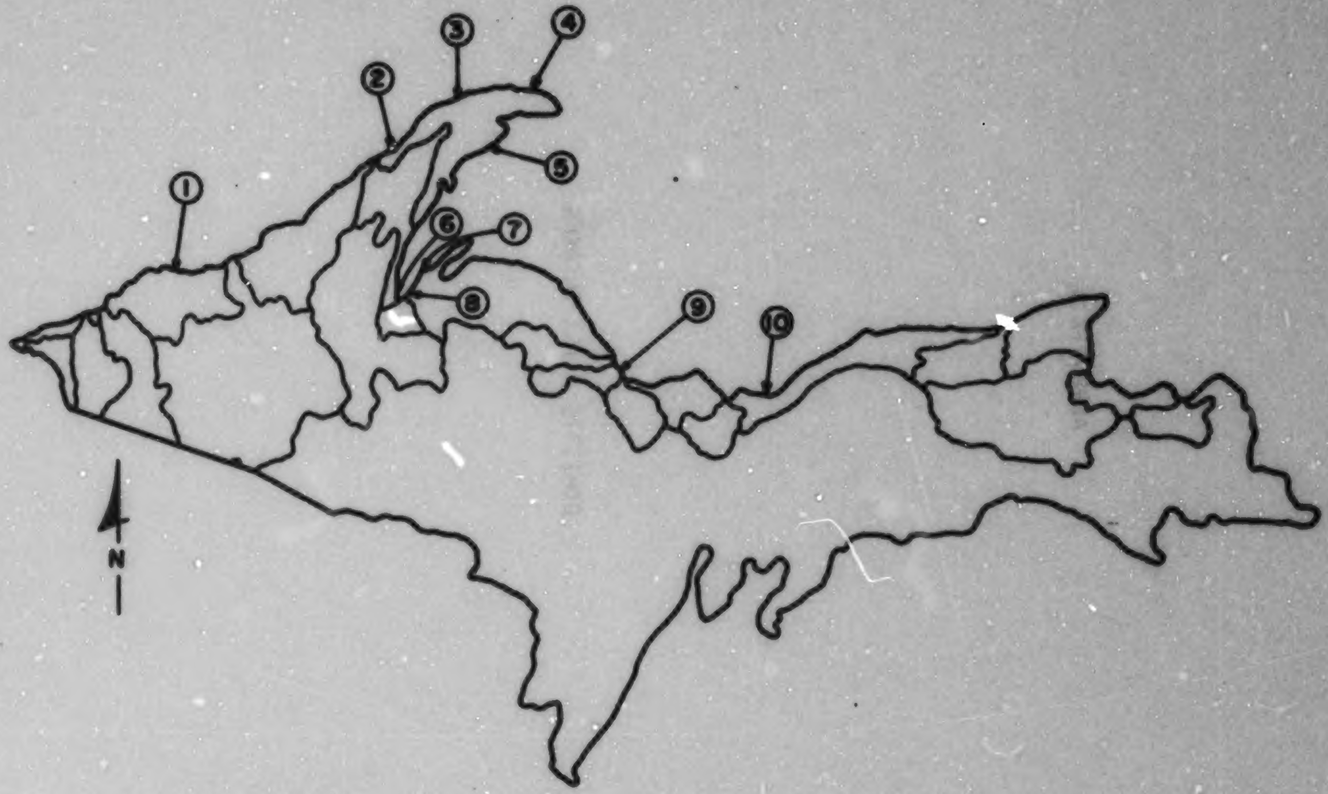
APPENDIX O

DOMESTIC WATER INTAKES

MAP 1

STATE OF MICHIGAN
MICHIGAN PORTION

LAKE SUPERIOR DRAINAGE BASIN
SAMPLING LOCATIONS – RAW WATER INTAKES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N

STATE OF MICHIGAN
MICHIGAN PORTION
LAKE SUPERIOR DRAINAGE BASIN
SAMPLE INFORMATION—RAW WATER INTAKES

Table 1

1968

Intake Sampled	Total Coliform MPN/100 ml	DO	BOD_5	SS	TDS	pH	NH_3-N	Cl	NO_3-N	SPO_4	TPO_4	Fe	Ca	Mg	Na	K	SO_4	Alkalinity $CaCO_3$	Hardness $CaCO_3$	F	Color (units)
1 White Pine Mine	< 20	11.6	1.6	1	62	7.6	0.25	0	0.0	0.00	0.00	0.0	16	2	1.4	0.5	2	66	62	0.20	5
2 Calumet	95	10.0	0.6	1	73	6.5	0.70	2	0.0	0.23	0.23	0.0	17	2	2.5	0.9	5	66	58	0.15	10
3 Eagle Harbor	< 20	12.2	0.6	3	59	7.3	0.25	0	0.0	0.00	0.00	0.0	15	1	1.7	0.6	1	66	62	0.10	5
4 Copper Harbor	< 20	12.2	0.4	7	70	7.6	0.20	0	0.0	0.00	0.00	1.7	13	1	1.6	0.5	7	66	58	0.10	5
5 Gay	< 20	8.8	1.9	4	84	6.8	0.35	0	0.0	0.00	0.00	0.4	17	2	2.5	1.1	5	55	52	0.15	10
6 Pequaming	< 20	11.6	2.6	2	65	7.3	0.20	0	0.0	0.20	0.00	0.1	15	1	1.6	0.5	4	66	67	0.15	5
7 Baraga	< 20	10.6	0.6	5	60	7.2	0.20	0	0.0	0.00	0.00	0.0	16	1	1.6	0.5	2	62	60	0.10	5
8 L'Anse	< 20	10.6	0.5	1	62	7.3	0.20	0	0.0	0.00	0.00	0.1	16	2	1.6	0.5	3	62	62	0.15	5
9 Marquette	< 20	——	——	2	56	7.3	0.25	0	0.0	0.02	0.00	0.0	16	1	1.6	0.5	3	62	60	0.10	5
10 Munising	< 20	10.4	0.6	3	62	7.4	0.30	0	0.0	0.05	0.00	0.0	16	1	1.7	0.5	1	62	60	0.20	0
Arithmetic Average		10.8	0.9	3	63	7.3	0.27	0	0.0	0.03	0.02	0.3	15	1	1.6	0.6	3	65	63	0.16	5.5

Table 2

1967

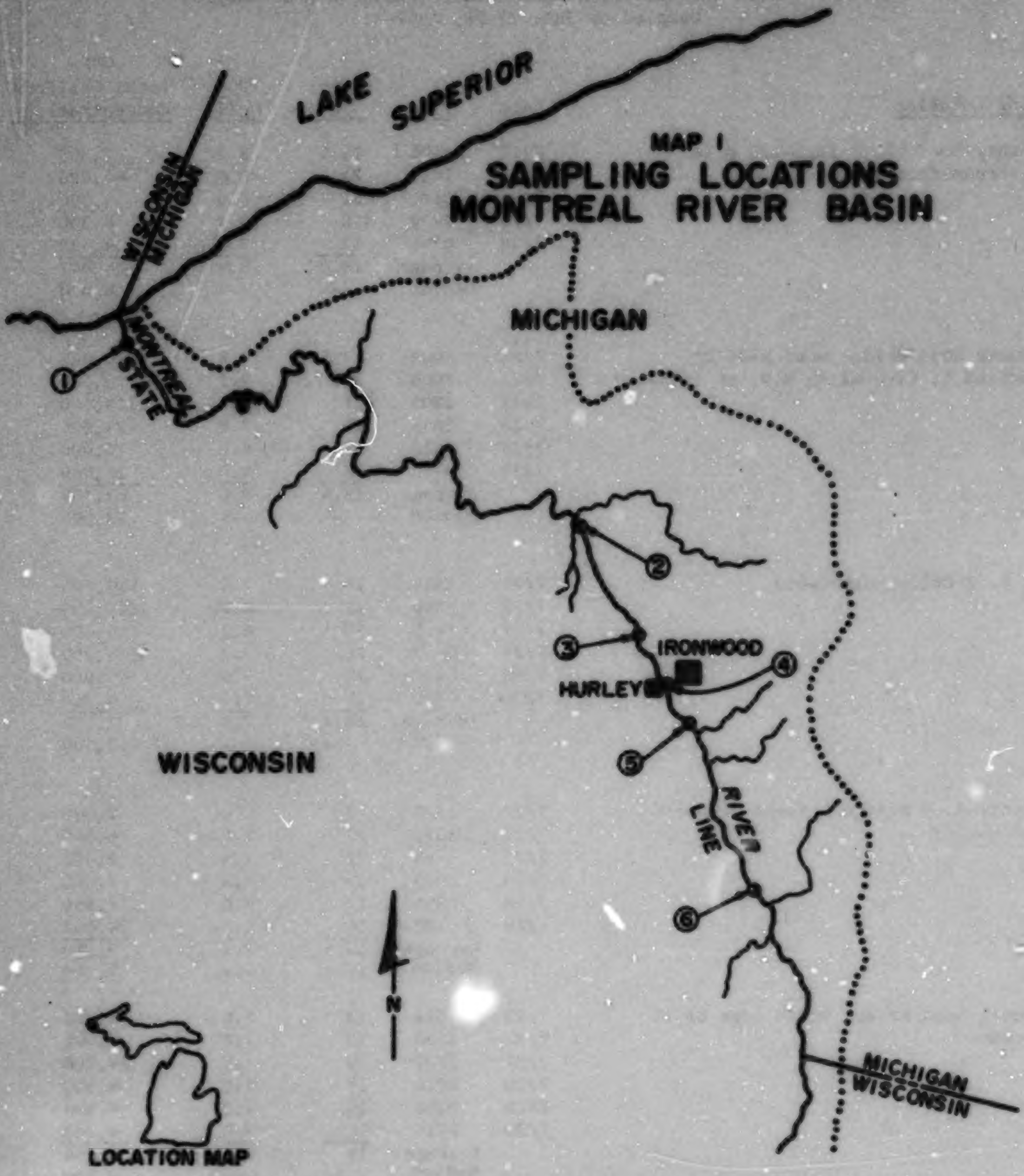
Intake Sampled	DO	BOD_5	SS	TDS	pH	NH_3-N	Cl	NO_3-N	SPO_4	Fe	Ca	Mg	Na	K	SO_4	Alkalinity $CaCO_3$	Hardness $CaCO_3$	CN	Cr^{+6}	As	Hg	Cu	F	Zn
1 White Pine Mine	13.1	1.6	2	67	7.8	0.25	0	0.0	0.00	0.0	16	2	1.8	0.4	4	65	60	0.00	0.00	0.00	0.0	0.0	0.10	0.0
2 Calumet	13.0	2.5	5	50	7.8	0.20	0	0.0	0.00	0.1	16	3	1.6	0.3	4	55	47	0.00	0.00	0.00	0.0	0.0	0.10	0.0
3 Eagle Harbor	12.5	1.7	1	65	7.7	0.25	0	0.0	0.00	0.2	16	4	1.6	0.3	3	50	52	0.00	0.00	0.00	0.0	0.0	0.10	0.0
4 Copper Harbor	11.6	1.8	0	50	7.7	0.25	0	0.0	0.00	0.0	16	4	1.6	0.3	6	50	52	0.00	0.00	0.00	0.0	0.0	0.10	0.0
5 Gay	6.6	0	0	70	7.3	0.25	0	0.0	0.00	0.3	15	4	2.5	0.6	5	55	56	0.00	0.00	0.00	0.0	0.0	0.10	0.0
6 Pequaming	10.8	2.6	6	50	7.9	0.70	2	0.0	0.00	0.1	16	4	1.8	0.3	3	55	50	0.00	0.00	0.00	0.0	0.0	0.15	0.0
7 Baraga	12.8	2.8	0	66	7.7	0.20	0	0.0	0.70	0.1	16	4	1.6	0.6	4	55	50	0.00	0.00	0.00	0.0	0.0	0.10	0.0
8 L'Anse	12.0	2.6	5	66	7.6	0.70	0	0.0	1.60**	0.0	15	3	1.8	1.6	7	60	50	0.00	0.00	0.00	0.0	0.0	0.15	0.0
9 Marquette	11.4	2.7	2	60	7.9	0.20	0	0.0	0.00	0.0	15	4	1.1	0.2	5	65	50	0.00	0.00	0.00	0.0	0.0	0.05	0.0
10 Munising			2	70	7.6	0.20	0	0.0	0.00	0.1	14	2	1.4	0.3	10	60	56	0.00	0.00	0.00	0.0	0.0	0.05	0.0
Arithmetic Average	11.5	2.0	2	55	7.7	0.3	0	0.0	0.15	0.1	16	3	1.6	0.5	5	46	50	0.00	0.00	0.00	0.0	0.0	0.10	0.0

NOTE: All results are expressed as mg/l except pH and as otherwise noted.
Sample results were obtained from grab samples taken during summer of 1967 & 1968.

** Source of high SPO_4 unknown.

APPENDIX P

MONTREAL RIVER BASIN



MAP 1

SAMPLING LOCATIONS MONTREAL RIVER BASIN

LAKE SUPERIOR
WISCONSIN
MICHIGAN
MONTREAL
STATE
MICHIGAN
①
②
③
④
⑤
⑥
IRONWOOD
HURLEY
RIVER
LINE
WISCONSIN
N
MICHIGAN
WISCONSIN
LOCATION MAP

TABLE 1
Interstate Water Quality Monitoring

Montreal River
Chemical, Physical and Bacteriological Measurements on Grab Samples
Sampled on July 27-28, 1967

Sampling Location	Date	Time	Temp. °C	DO mg/l	MPN Total Coliform Concentration
1. County Road 505 Bridge 1/2 mile upstream from mouth	7/27	1105	19.5	8.0	2,300
	7/27	1415	21	8.0	46,000
	7/27	1840	21	8.6	4,300
	7/28	0430	18	8.2	4,300
	7/28	0745	17	9.0	4,300
		Average	19.3	8.4	4,017
		Median	----	---	4,300
2. County Road Bridge west side of Section 5, five miles N.W. of Ironwood	7/27	1038	17.5	8.8	110,000
	7/27	1400	20	8.2	110,000
	7/27	1805	21	7.4	110,000
	7/28	0045	19	7.6	24,000
	7/28	0410	17	8.0	46,000
	7/28	0730	16	8.0	15,000
		Average	18.4	8.0	69,167
		Median	----	---	78,000
3. U. S. 2 Bridge, Ironwood	7/27	1028	18	7.4	110,000
	7/27	1350	19	6.8	140,000
	7/27	1755	21	6.2	140,000
	7/28	0037	21	7.2	110,000
	7/28	0400	17	7.0	46,000
	7/28	0725	16	7.2	9,300
		Average	18.7	7.0	92,550
		Median	----	---	110,000
4. County Road Bridge between Ironwood and Hurley	7/27	1020	18	7.0	2,300
	7/27	1340	20	7.0	4,300
	7/27	1745	21	7.4	9,300
	7/28	0030	19	7.4	7,500
	7/28	0355	17	7.0	7,500
	7/28	0720	16	6.8	24,000
		Average	18.5	7.1	9,150
		Median	----	---	7,500
5. County Road Bridge south edge of Ironwood	7/27	1011	18	7.6	4,300
	7/27	1330	19	7.6	2,300
	7/27	1732	20	7.2	24,000
	7/28	0020	19	7.0	4,300
	7/28	0350	16	7.2	4,300
	7/28	0710	16	7.6	4,300
		Average	18	7.4	7,250
		Median	----	---	4,300
6. County Road Bridge to VanBuskirk, Wisconsin	7/27	1000	16.4	6.6	4,300
	7/27	1320	19	6.6	36
	7/27	1720	20	7.0	930
	7/28	0005	19	6.6	930
	7/28	0335	17	7.0	91
	7/28	0700	16	6.4	91
		Average	17.9	6.8	1,063
		Median	----	---	510

TABLE 2

Interstate Water Quality Monitoring
Montreal River
Chemical and Physical Measurements on 24 Hour Composite Samples
Sampled on July 27-28, 1967

Sampling Location	BOD_5	C.O.D.	S.S.	T.D.S.	pH	NO_3-N	Cl	NH_3-N	S.O. PO_4	Total PO_4	Fe	Ca	Mg	Na	K	SO_4	Alkal.	Color	Hardness	ABS	Phenol	Cn	Cr^{+6}	Rad. μc/ml X10-7	[illegible]	[illegible]	F	Zn
1 Co. Rd. 505 Bridge 1/2 mile upstream from mouth	3.0		9	110	7.5	0.00	0	0.0	0.05	0.20	0.60	15	3	2.3	3.5	3	42	120	50	0.0	0.00	0.00	0.00	.10	0.0	0.0	0.33	0.0
2 Co. Rd. Bridge, W. Side of Sec. 5, 5 miles N.W. of Ironwood	3.4		9	110	7.3	0.30	0	0.0	0.55	0.55	--	17	2	3.2	3.6	-	46	-	50	0.0	--	0.00	0.00	--	0.0	0.0	0.30	0.0
3 U.S. 2 Bridge, Ironwood	2.8	Composite of all - 8	16	110	7.2	0.00	0	0.0	0.05	0.10	--	[illegible]	3	[illegible]	2.4	-	42	-	45	0.0	--	0.00	0.00	--	0.0	0.0	0.23	0.0
4 Co. Rd. Bridge between Ironwood & Hurley	2.5		10	110	7.1	0.00	0	--	0.00	0.15	0.80	12		.4	2.3	3	36	170	35	--	0.00	0.00	0.00	.04	0.0	0.0	0.18	0.0
5 Co. Rd. Bridge, S. Edge of Ironwood	3.1		9	110	7.1	0.00	0	--	0.00	0.15	--	[illegible]		.6	2.4	-	34	--	35	--	--	0.00	0.00	--	0.0	0.0	0.25	0.0
6 Co. Rd. Bridge to Van Buskirk, Wisc.	3.3		7	110	7.0	0.00	0	0.0	0.00	0.15	0.75	12	[illegible]	.4	2.3	-	34	180	35	0.0	0.00	0.00	0.00	--	0.0	0.0	0.25	0.0

NOTE: All concentrations except color, turbidity, and radioactivity are expressed [illegible]

APPENDIX Q

WATER QUALITY SURVEY OF LAKE SUPERIOR IN THE MARQUETTE VICINITY

MICHIGAN WATER RESOURCES COMMISSION

Water Quality Survey of Lake Superior in the Marquette Vicinity

August 8-11, 1968

A water quality survey of the Marquette area was requested by District Engineer Joseph Bal to determine the effects of various waste discharges on the aquatic life of Lake Superior. Observations and surveys were made on benthic macroinvertebrate communities, aquatic habitat conditions and water quality conditions with respect to industrial and municipal waste discharges and an electrical power plant thermal discharge. Observations on water quality were made on rivers tributary to this vicinity of Lake Superior.

Macrofauna Survey Methods

Quantitative collections of bottom dwelling macroinvertebrates were made with Ponar dredge hauls in Lake Superior. A U. S. Standard #30-mesh bucket sieve was used for sieving the samples. Thirty man-minute qualitative macroinvertebrate collections were made at each Carp River station by hand picking and with a long-handled dip net. Qualitative collections at each Dead River station consisted of several partial Ekman dredge hauls. All samples were preserved with formalin and labeled in the field. Organisms were washed, sorted, identified, and tabulated in the Lansing laboratory. Animals were assigned a tolerance status according to published accounts and the past experience of the biology staff of the Water Resources Commission.

Tolerance status may be generally defined as:

Tolerant-organisms that can grow and develop within a wide range of environmental conditions. They are often found in water of poor quality. These species are generally insensitive to a variety of environmental stresses.

Intolerant-organisms whose growth and development are dependent upon a narrow range of optimum environmental conditions. They are rarely found in areas of organic enrichment. They cannot adapt to adverse situations and are replaced by less sensitive organisms if the quality of their environment is degraded.

Facultative-organisms with the ability to survive over a wide range of conditions. They possess "medium" tolerance and often respond positively to moderate organic enrichment but cannot tolerate severe environmental stresses.

In addition to tolerance status, the diversity of animals present in a given benthic community is significant. In general, pollutional communities are characterized by very low species diversity, while normal undisturbed communities contain many different species.

Bottom Sampling and Observations

Interrelationships between the benthic animals and their environment based on the sampling detailed below are tabulated, summarized, and depicted in Figure 1 and Tables 1 through 9(all figures are in Appendix Q-A and all tables are in Appendix Q-B). These graphs and summaries show a well balanced clean water benthic community in the Dead River, most of the areas sampled in Lake Superior and above the Marquette Wastewater Treatment Plant(WWTP) outfall in the Carp River. An unbalanced pollution tolerant community inhabited the lower reaches of the Carp River and a small area in Lake Superior off the Carp River mouth.

TRIBUTARIES

Dead River - Stations 1,2 and 3

Qualitative biological samples were collected with an Ekman dredge at 5 foot depths in the Dead River(Figure 2). Bottom sediments consisted of wood, bark, plant detritus, and silty sand. Dominant animals were oligochaetes, midges and leeches. However, pollution-sensitive mayflies and caddisflies were present at all stations. A well balanced clean-water community was found at all three stations.

Carp River - Stations 1 and 2

Station 1 was located 500 feet above the Marquette WWTP. The sample was collected from the stream margin out to a 2½ foot depth. The bottom sediments consisted of small rocks and gravel. This area had the appearence of a productive clean water stream. Dominant animals were mayflies, caddisflies and midge larvae. This station supported a diversified fauna typical of a clean stream. Of the 28 species found 4 were tolerant, 18 were facultative, and 6 were intolerant.

Station 2 was located 500 feet below the Marquette WWTP outfall. The sample was collected from the stream margin out to a 2½ foot depth. The substrate consisted of small rocks and gravel covered with sewage fungus. A strong sewage odor was emitted from the turbid waters. Animal species were found to be severely reduced in both numbers and quality from those found at station 1. Sludgeworms were extremely abundant followed by flatworms and midge larvae. Only 6 species were found of which 3 were tolerant and 3 were facultative. None of the intolerant clean-water types were found. This area supported an unbalanced pollution-tolerant community.

LAKE SUPERIOR

For purpose of illustration and comparison the study area was divided into seven areas(Figure 3).

Area I

A total of 8 stations were sampled in this area at depths between 11 and 35 feet (Figure 4). However, no sample was obtained at station 4 because the bottom was bedrock. The bottom sediments at the remaining stations consisted of sand, small stones, red clay, iron ore pellets and a small amount of organic detritus(the latter was found only at station 5). Dominant animals found in this area were oligochaetes, midges and the amphipod *Pontoporeia affinis*(Table 3). The highest number of species found was at station 1 where 13 were present. The largest population of oligochaetes(mostly *Tubifex tubifex*) found in the Lake Superior samples was found at station 5. This station had a thin organic detritus layer covering the bottom sediments.

The Upper Peninsula Power Company uses the entire flow of the Dead River along with Lake Superior water for cooling purposes. These heated waters are then discharged to Lake Superior just north of the Dead River mouth. The natural sediment load transported to Lake Superior from this river has a slight enriching effect on the benthos in area I. Temperature observations in this area show a deflection of these heated waters to the south because of the ore dock.

Stations 1 and 5, which were affected by these waters, had a relatively large number of tolerant sludgeworms(*Tubifex tubifex*). At station 1, 7 of the 13 species found were tolerant and 6 facultative. No intolerant animals were found at this station. Four of 6 species found at station 5 were tolerant. The benthos at stations 6 and 8 were also influenced to a much lesser degree by the Dead River waters.

Other stations(2,3, and 7) which were apparently outside the influence of the river had no tolerant sludgeworms and only small numbers of facultative worms. A more normal community was found at these stations.

Area II

Six stations were sampled in this area at depths between 21 and 37 feet(Figure 4). The bottom sediments consisted of coarse to fine sand, coarse gravel, red clay, iron ore pellets, and a small amount of organic detritus at station 2. Dominant animals were oligochaetes, midges, and amphipods(Table 4).

The Royal Oak Charcoal Company, a destructive wood distillation company, discharges wastewater to the northern half of area II. The limited data obtained in this vicinity indicated that this discharge had little if any effect on the bottom fauna.

The shallow inshore waters(stations 1,2 and 3) were less productive in both species and number of individuals than were the deeper offshore waters(stations 4,5 and 6). Increased numbers of facultative organisms were inhabiting the deeper waters(Figure 1). Intolerant scuds(Pontoporeia affinis) were found at all stations, but were abundant in the deeper waters. Shallow, sandy, shoreline areas subjected to wave action provide an unstable habitat for bottom dwelling animals.

The restricted macro-faunal community found at station 1 was probably the result of poor habitat(iron ore pellets). In contrast to area I all stations in this area contained very limited populations of sludgeworms.

Area III

Bottom samples were collected from 4 of the 6 stations in this area(Figure 5). No samples could be obtained at stations 4 and 5 where the bottom was bedrock. The 4 stations sampled had a sand bottom with depth range from 10 to 26 feet. Dominant animals were midges, oligochaetes and amphipods(Table 5). The highest number of species was found at station 6 where 11 were present.

Area III does not receive any wastewater discharges. There was no indication of any water quality impairment in this area. The three samples(stations 1,2, and 3) taken in shallow water were low in productivity because of shifting sand, as were those in area II. However, station 6, which was in deeper water, was relatively productive(Figure 1). Normal populations of scuds(Pontoporeia affinis) were found at 3 of the 4 stations sampled. Sludgeworms were not abundant.

Area IV

Six stations were sampled in this harbor area at depths between 7 and 25 feet (Figure 5). The bottom sediments at stations 1 through 5 consisted of sand covered by a thin layer of organic detritus. Detritus deposition is probably natural in quiet harbor waters. Sandy sediments at station 6 were not covered by organic detritus.

Animals found in this area were predominately oligochaetes, midges, amphipods, and aquatic sow bugs(Table 6).

The presence of sewage-fungus, toilet tissue, and sewage-odor at the mouth of Orianna Brook indicated that small amounts of sewage were reaching the lake from this source(Figure 5). A cutting oil odor was observed in the sandy sediments at station 6 which was near this tributary mouth. The bottom-dwelling animals at this station were adversely affected by these wastes. Sixty-nine of the 75 animals found here were tolerant. Numbers of facultative animals were greatly depressed and intolerant animals were entirely absent(Figure 1). In contrast to this, stations 1 through 5 had greater variety and larger populations of animals than areas I, II, and III. Organic detritus encourage such aquatic production.

Area V

Three of the seven samples taken in this area were collected at 15 foot depths(Stations 1,2, and 3). Samples at the other four locations(stations 4,5,6 and 7) were taken at depths ranging from 25 to 34 feet. Bottom sediments consisted of sand. However, at station 7 the sand was covered with a layer of organic detritus. Dominant animals found were oligochaetes amphipods and midges.

The only wastewater discharge in this area is the cooling water from a small electrical power station. This small heated plume follows the shoreline for a short distance to the south.

The three inshore samples had benthic communities low in productivity similar to those found in the inshore waters of areas II and III(Table 7). As found elsewhere the offshore communities had higher populations. They were different however, in that they contained a higher percentage of sludgeworms. These higher populations were significantly lower than those usually found in enriched waters. All offshore samples contained large populations of scuds(Pontoporeia affinis) and a variety of facultative midges.

Area VI

The ten stations in this area were sampled at depths between 5 and 35 feet (Figure 6). Sandy sediments were found at all stations. A thin layer of algal or organic detritus covered the sand at stations 1, 2 and 3. A sewage odor was detected in the sediments at all stations except station 7 and 10.

The Marquette WWTP discharges to the Carp River approximately 500 feet above the river's entrance to Lake Superior. The aquatic biota in the lower reaches of the Carp River has been reduced to a pollution-tolerant community because of this discharge. However, the effects in the lake are not as severe.

There were unusually turbid waters present at the three stations(Stations 1, 2 and 3) nearest the Carp River. The sediments here imparted a strong sewage odor. The benthic communities found here included the same species composition as the offshore samples but, had a marked reduction in number of clean-water scuds(Pontoporeia affinis) and included tolerant midges(Tendipes riparius and T. anthracinus) in unusually large numbers(Table 8). Offshore samples(Stations 4, 5,6,7,8,9 and 10) contained lower numbers of clean-water scuds(Pontoporeia affinis) than other offshore areas.

Midges were dominant in area VI and were twice as abundant as found elsewhere. This was true both in number of individuals and variety of species(Figure 1). This is undoubtably caused by slight enrichment introduced by the Carp River.

Area VII

The depth range for the 7 stations sampled in this area was 14 to 35 feet (Figure 6). Clean sand was found at all stations except 1 and 4 where a thin algal and detritus layer covered the sand.

The benthic animal population was much lower in this area than in the other areas. The average number of organisms per square foot for the entire survey was: 112 at 5 to 16 foot depths; 158 at 17 to 25 foot depths; and 125 at 26 to 35 foot depths. For area VII however, the averages were only 28 at 5 to 16 foot depths; 51 at 17 to 25 foot depths; and 63 at 26 to 35 foot depths. Larger benthic populations were found in the deeper waters similar to the other areas.

The tolerant midge(Tendipes riparius) was found at all stations except station 7 and the clean-water scud(Pontoporeia affinis) population was almost eliminated (Table 9). This indicates that the wastewater from the Marquette WWTP has had a slight effect on this area. This was indicated by the biotic index for this area which was the second lowest for the seven areas(Table 9). Only area 1 had a lower index value.

Algae sampling and observations

Attached algae was scraped from hard substrates such as rocks, cement slabs and old pilings along the Marquette vicinity shoreline. Planktonic algae were collected either in a 3 minute net tow or by grab sampling. Algae samples were collected at 13 locations between Presque Isle Point and the Chocolay River(Figure 7). The attached or planktonic algae composition which occurred at the various locations are presented in Table 10. Sedgwick-Rafter cell counts were made on all quantitative samples. These counts were all low with a range of 17 to 140 cells/ml. The dominant forms of attached filamentous algae were Ulothrix, Stigeoclonium, and Cladophora. The bulk of the planktonic algae were diatoms. However, planktonic blue-green algae were found at stations 9 and 10 which bracket the Carp River mouth. Station 9 was 50 yards north of the river and station 10 was 50 yards south of the river.

Water Chemistry

Water samples collected from 11 stations in Lake Superior were analyzed for their phenolic content(Figure 8 and Table 11). Laboratory results showed that the phenolic concentrations of the surface waters ranged from 0 to 12 ppb while samples near the bottom contained 0 to 4 ppb. This type of phenol has been reported to cause fish taint when concentrations exceed 20 to 100 ppb. Reports also show that toxicity to fish occurs between 200 and 20,000 ppb depending upon the particular phenolic compound. The Royal Oak Charcoal Company boiler and condenser water discharge located along the Lake Superior shoreline in front of the plant had a phenolic concentration of 800 ppb while Hawley ditch which receives the overflow from their settling ponds had a concentration of 1200 ppb. This ditch had a very strong creosote odor. A Michigan Water Resources Commission wastewater survey conducted August 27-29, 1968 reported a substantial reduction in the phenolic load to Lake Superior since their 1959 survey. No complaints have been received concerning taste or odor problems in the Marquette City water supply from Lake Superior nor have complaints been received of off-flavored fish from this area.

Thermal discharge investigation

A temperature survey was conducted on August 8, 1968 in Lake Superior in the vicinity of the Upper Peninsula Power Company fossil fuel plant. This plant, located north of Marquette at the mouth of the Dead River, operates at a capacity of 180 megawatts electrical. The condenser cooling water is taken from the Dead River and is discharged to the shoreline of Lake Superior just north of the Dead River.

On the day of this survey 76,500 gallons of water per minute(170 cfs) were being used for cooling purposes. The intake water temperature was 73° F and the discharge temperature was 94° F. This plant does not experience diurnal fluctuations in electrical demand as often occurs in plants serving municipalities because its main consumer is the mining industry. This industry operates twenty-four hours per day. Chlorine is added to the intake water each day in the months of June, July and August to discourage algal growths in the condensers.

The water temperature survey was conducted between 1:00 PM and 3:00 PM. The wind was from the northwest at 0-5 mph.

Surface temperatures found in the vicinity of the plant are shown on Figure 9.

Temperature profiles taken at six locations in the offshore waters are shown in Figure 10.

Within 100 feet of its entrance to Lake Superior the warm water floated at the surface.

The plume was diverted north, along the shoreline, for a short distance by a sand bar near the mouth of the discharge, before moving into offshore waters. When the plume finally encounters actual lake water, approximately 300 feet to the north, it occupies only the upper two feet of water. The temperature was 82° F in the upper two feet and only 66° F in the bottom two feet. Four hundred feet further offshore the temperature declined to 75° F at the surface, 66° F at two and one-half foot depth and 64° F between five foot depth and the bottom. The four additional sampling stations within a one mile radius of the discharge showed the same trend.

Water temperatures in the heated plume dropped rapidly from 93° F to 73° F in the first 1,000 feet of travel. Beyond this point the plume lost its identity and became intermixed with the cooler lake water. Occasional warm areas, remnants of the original plume, were detected 2,000 feet offshore. The heated water traveled approximately 4,000 feet to the SE before it dropped to within three degrees of the ambient temperature of 63° F. Since warm water masses were scattered among cooler waters it is difficult to determine the area warmed by the plant discharge. A rough estimate indicates that 80 acres of surface water were raised more than 10° F and 240 acres were raised more than 5° F.

This small thermal load to Lake Superior appears to be benificial to water use. The immediate area of the discharge is widely used for swimming. Lake Superior waters are generally too cold for most swimmers.

Fishermen use the open water area created by this discharge during ice cover to good advantage.

DISCUSSION OF LAKE SUPERIOR DATA

This water quality survey was conducted to determine if wastewater discharges in the Marquette area have had any adverse affects on the biota of Lake Superior.

Bottom-dwelling macroinvertebrates were collected along seven miles of shoreline out to depths of 35 feet. For purposes of illustration and comparison, the study area was divided into seven sub-areas(Figure 1).

In general, the chemical and biological findings indicate that the effects of wastewater discharges in these areas were very limited.

Alterations of the benthic communities studied were limited to scattered inshore areas and were difficult to define. The bottom-dwelling communities along the sandy shores of Lake Superior are characterized by low numbers of individuals and the presence of the clean-water scud(Pontoporeia affinis). The clean shifting sand bottom is an unstable habitat which does not support a large community. Deeper water habitats tend to support more animals, especially P. affinis. Both of these areas support only a small number of aquatic worms(Oligochaeta) and midges (Tendepedidae). The benthic communities in areas II and III are examples of this phenomenon.

Small quantities of organic sediments found in the inshore protected harbor waters of area I apparently originate from the Dead River.

Organic sediments were found at most stations in area IV. Quiet harbor waters, intensive shoreline development and high boating and shipping use are factors involved in this sedimentation. Orianna Brook also contributes some organic sediments to this area.

A thin layer of organic sediments was found in areas VI and VII. These sediments originate from the Carp River.

The bottom-dwelling communities in the areas where organic sediments have accumulated are characterized by increased numbers of individuals, including larger sludgeworm populations. These organic sediments modify the habitat and provide an increased food source, thus supporting larger benthic communities.

The two harbors(areas I and IV) and areas VI and VII(off the Carp River mouth) had some organic sediment accumulations. Larger benthic communities were found in these areas. These increases were largely reflected in numbers of individuals (mostly sludgeworms) in areas I and IV and species diversity(mostly midges) in areas VI and VII.

Bottom fauna community changes in areas VI and VII are the result of the Marquette WWTP discharge to Lake Superior, via the Carp River. These changes are not pronounced, but do suggest a lessening of the overall quality of the environment. This decrease in quality was further substantiated by increased turbidity and blue-green algal growths in the immediate vicinity of the Carp River mouth.

The biota in area I was not adversely affected by the Upper Peninsula Power Company thermal discharge to Lake Superior. Changes in the biota of this area are attributed entirely to the contribution of materials from the Dead River.

The Royal Oak Charcoal Company wastewater outfalls are located along the Lake Superior shoreline in area II. No adverse environmental affects were attributed to this discharge. The benthic community structure in this area was very similar to the unproductive clean water community found in area III.

SUMMARY

1) On August 8-11, 1968 a water quality survey was conducted to determine the effects of various wastewater discharges on the biota of Lake Superior and its major tributaries in the Marquette vicinity.

2) A well balanced clean-water benthic community was found at all Dead River stations.

3) A well balanced clean-water benthic community was found above the Marquette WWTP in the Carp River. A very restricted pollution-tolerant community was found below this outfall. Profuse slime growths, septic odors and turbid waters were evident in the lower river reach.

4) Productivity of benthic animal life in the sand, sand-rock substrates of nutrient-poor Lake Superior was generally low. The shallower inshore areas with unstable substrates supported even lower numbers of benthic animals than the deeper offshore waters.

5) Some modification of the physical environment and biological community structure of Lake Superior was evident at scattered locations near Marquette.

6) The Upper Peninsula Generating Company had a 21° F temperature differential between intake and discharge waters. Their heated discharge warmed approximately 80 acres of Lake Superior surface waters by more than 10° F and approximately 240 acres by more than 5°F. No adverse biological effects from increased temperatures were evident in this survey.

7) The Dead River water, cycled through the U. P. Generating Company, contributes a natural organic loading to Lake Superior. This natural enrichment has increased the benthic productivity of a small offshore area. This increased productivity is primarily reflected in pollution tolerant organisms.

8) The Royal Oak Charcoal Company, a destructive wood distillation plant, discharges phenolic wastes to Lake Superior. During this survey phenols in their two discharges were measured at 800 and 1200 ppb. Phenolic concentrations in Lake Superior ranged from 0-12 ppb in surface waters and 0-4 ppb in bottom waters. No complaints have been received concerning taste or odor problems in the Marquette City water supply from Lake Superior and no complaints have been received of off-flavored fish from this area. No adverse effects to benthic animal communities in close proximity to these discharges were detected.

9) This organic sedimentation was evident in the Marquette Harbor vicinity. Sedimentation was enhanced by the quiet protected harbor waters, intensive shoreline development and intensive boating and shipping use. Orianna Brook, an apparent recipient of sewage wastes, enters this harbor. Benthic studies found greater numbers of both species and individuals with no apparent increase in pollution-tolerant forms. This increased productivity is characteristic of an environment enriched by organic sedimentation.

10) The Marquette WWTP discharge to Lake Superior, via the Carp River, has resulted in benthic animal community alterations. These changes were not pronounced, but did suggest a lessening of the overall quality of the environment. This decrease in quality was further substantiated by increased turbidity, sewage odors, and blue-green algal growths in the immediate vicinity of the Carp River mouth.

11) The water quality of Presque Isle and Marquette Harbors were slightly impaired in small, scattered, localized areas. The overall water quality of Lake Superior in this vicinity was not adversely affected by natural or artifical sources.

Field and laboratory work supervised by:	D. James Seeburger, Aquatic Biologist
Report by:	D. James Seeburger John G. Robinson, Aquatic Biologist Ronald B. Willson, Aquatic Biologist

APPENDIX Q-A

Table 1. Benthic animals found in a qualitative biological survey of the Dead River, Marquette County, Michigan, August 9, 1968.

Tolerance Status	Species	Station: 1 Depth: 5'	2 5'	3 5-8'
T	Oligochaete	A*	A	C
T	Tubificidae	A	VA	O
F	*Stylaria fossularis*	C		
T	*Limnodrilus hoffmeisteri*			A
	Hirudinea			
T	*Helobdella stagnalis*		C	VA
T	*Glossiphonia stagnalis*	P		P
T	Arhynchobdellidae	P		P
F	Turbellaria	O		
F	Planariidae	P		
F	Nematoda		P	
	Isopoda			
T	*Asellus militaris*	O	A	VA
	Gastropoda			C
F	*Gyraulus* sp.			P
F	*Amnicola* sp.		P	P
	Pelecypoda			
T	*Sphaerium* sp.	P		O
F	*Elliptio* sp.	P	P	
	Ephemeroptera			
I	*Hexagenia limbata*	P	P	
F	*Caenis* sp.			P
	Trichoptera			
I	*Phylocentropus* sp.	C	P	P
I	Limnophilidae			P
	Lepidoptera			
	Pyralidae (Nymphulini)			O
	Diptera			
	Tendipedidae (pupae)**			C
T	*Procladius adumbratus*	A		
T	*Pentaneura flavifrons*		P	A
F	*Limnochironomus* sp.			VA
I	*Hydrobaenus nivoriundus*		P	
F	*Calopsectra dives*	O	P	P
F	*Cryptochironomus demeijerei*			O
F	*Cryptochironomus digitatus*	O	P	P
	Total number species	15	13	20
	Number tolerant species(T)	7	5	9
	Number facultative species(F)	6	5	9
	Number intolerant species(I)	2	3	2
	Biotic index	10	11	13

*(VA = very abundant, A = abundant, C = common, O = occasional, P = present)

** pupae are not tabulated in summary totals

Table 2. Benthic animals found in a qualitative biological survey of the Carp River, Marquette County, Michigan, August 8, 1968.

Tolerance Status	Species	Station:	1	2
T	Oligochaeta		O	
	Tubificidae			
T	*Tubifex tubifex*			VVA**
	Amphipoda			
I	*Crangonyx shoemakeri* or *gracilis*		O	
F	*Hyalella azteca*		P	
	Decapoda			
F	*Orconectes* sp.		O	
	Isopoda			
T	*Asellus militaris*		C	
F	Turbellaria			
F	Planariidae		O	VA
	Gastropoda			
T	*Physa* sp.		P	
	Megaloptera			
F	*Sialis* sp.		P	
	Coleoptera			
F	*Hydroporus* sp.		O	
F	*Optioservus* sp.		P	
	Ephemeroptera			
I	*Heptagenia* sp.		C	
F	*Centroptilum* ? sp.		O	
F	*Baetis* spp.		A	
	Trichoptera			
I	*Brachycentrus americanus*		A	
I	*Agraylea*? sp.		P	
F	*Hydropsyche* sp.		C	
F	*Hydropsyche bifida* gp.		C	
F	*Cheumatopsyche* sp.		A	
I	*Paraleptophlebia* sp.		P	
	Diptera			
F	*Simulium* spp.		A	
I	*Atherix variegata*		P	
	Tendipedidae (pupae)*		O	
T	*Pentaneura* sp.		C	
T	*Prodiamesa olivacea*			O
F	*Metriocnemus* sp.			VA
F	*Cricotopus elegans*		A	
F	*Cricotopus* sp.		VA	
F	*Calopsectra* sp.		P	
F	*Tanytarsus* sp.			C
F	*Polypedilum* sp.		A	
F	*Cryptochironomus digitatus*		P	
T	*Tendipes riparius*			P
	Fish			
F	*Cottus bairdii*		P	
	Number species present		28	6
	Number tolerant species		4	3
	Number facultative species		18	3
	Number intolerant species		6	0
	Biotic index		30	3

* pupae are not tabulated in summary totals

** (VVA = very very abundant, VA = very abundant, C = common, O = occasional and P = present)

Table 3. Benthic animals found in a biological survey of Presque Isle Harbor, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species		AREA I							
		Station:	1	2	3	4	5	6	7	8
		Depth:	11'	12'	12'	21'	21'	21'	34'	35'
T	Oligochaeta		30	11	9				4	30
	Tubificids:									
F	*Potamothrix moldaviensis*		86							
F	*Peloscolex ferox*		42				87			25
T	*Tubifex tubifex*		124				550			
T	*Limnodrilus hoffmeisteri*							21		83
	Amphipoda									
I	*Pontoporeia affinis*			14	2		20	2		4
	Pelecypoda									
T	*Pisidium* sp.		4		5		2			
	Diptera									
F	*Bezzia* sp.		2							
	Tendipedidae (pupae)*			16	9					
T	*Pentaneura flavifrons*		2		5				2	
T	*Procladius adumbratus*		9				5			
T	*Procladius* sp.		2							
I	*Hydrobaenus* [illegible]				33					
F	*Psectrocladius simulans*		39							2
T	[illegible]		5		16		4			1
F	*Stictochironomus flavicingula*		5							
F	*Cryptochironomus digitatus*		2						4	
F	*Harnischia* [illegible]			30						
F	*Psectrocladius* sp.			80						
	Number species present		13	4	6		6	2	3	6
	Number animals/sq. ft.		352	135	60		668	23	10	146
	Number tolerant species(T)		7	1	4		4	1	2	4
	Number tolerant animals(T)		176	11	35		561	21	6	119
	Number facultative species(F)		6	2	0		1	0	1	2
	Number facultative animals(F)		176	110	0		87	0	4	27
	Number intolerant species(I)		0	1	2		1	1	0	0
	Number intolerant animals(I)		0	14	35		20	2	0	0
	Biotic index		6	4	4		3	2	1	2

* pupae are not tabulated in summary totals

Table [illegible]. Benthic animals found in a biological survey of Presque Isle Harbor, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species		AREA II					
		Station:	1	2	3	4	5	6
		Depth:	21'	21'	21'	37'	34'	34'
T	Oligochaeta					11		2
T	Tubificidae			2				
F	*Bothrioneurum vejdovskyanum*		5			5		7
F	*Stylaria fossularis*					20		
F	*Aulodrilus americanus*						12	
F	Naididae							
F	Nematoda					4		2
F	Cladocera						21	11
	Amphipoda							
I	*Pontoporeia affinis*		5	7	23	81	5	58
	Diptera							
	Tendipedidae (pupae)*			18	7		2	2
T	*Procladius adumbratus*					2		
I	*Hydrobaenus nivorlunda*		2	7				
F	*Psectrocladius simulans*				9			
F	*Cricotopus fugax*				2	2	9	
F	*Metriocnemus lundbecki*					5	18	2
F	*Eukiefferiella brevinervis*						2	
F	*Trichocladius* sp.						2	
F	*Calopsectra dives*				12	7	98	
F	*Xenochironomus xenolabis*							2
F	*Polypedilum flavus*				5		2	
F	*Polypedilum* sp.			18		2	5	
F	*Cryptochironomus demerijeri*				2			
F	*Cryptochironomus digitatus*					2		
F	*Cryptochironomus* sp.					2		
T	*Prodiamesa bathyphila*					2		
F	Fish fry (*Cottus?*)							4
	Number species present		3	4	6	13	10	8
	Number organisms/sq. ft.		12	34	54	147	176	89
	Number tolerant species(T)		0	1	0	3	0	1
	Number tolerant animals(T)		0	2	0	15	0	2
	Number facultative species(F)		1	1	5	9	9	6
	Number facultative animals(F)		5	18	31	50	170	69
	Number intolerant species(I)		2	2	1	1	1	1
	Number intolerant animals(I)		7	14	23	81	5	58
	Biotic Index		5	5	7	11	11	8

* pupae are not tabulated in summary totals

Table 5. Benthic animals found in a biological survey of Marquette Bay, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species	Station: Depth:	AREA III 1 21'	2 10'	3 16'	4 34'	5 35'	6 27'
T	Oligochaeta		7		5			4
T	Tubificidae							
F	Stylaria proboscidea		9					
F	Bothrioneurum vejdovskyanum				20			
F	Potamothrix vejdovski							5
F	Cladocera				28			11
F	Nematoda							2
	Planariidae							
F	Dalyellia ? sp.				2			
	Amphipoda							
I	Pontoporeia affinis		14		23			32
F	Copepoda							4
	Diptera							
	Tendipedidae (pupae)☆		4	11	12			9
F	Psectrocladius simulans							4
F	Psectrocladius sp.		11					9
F	Cricotopus fugax							2
F	Metriocnemus lundbecki			2				
F	Calopsectra dives							2
F	Calopsectra bausei			9				
F	Polypedilum flavus		4					
F	Polypedilum sp.				11			32
F	Cryptochironomus demeijeri			20				
	Number species present		5	3	6			11
	Number of organisms/sq. ft.		46	31	90			109
	Number tolerant species(T)		1	0	1			1
	Number tolerant animals(T)		7	0	5			4
	Number facultative species(F)		3	3	4			9
	Number facultative animals(F)		24	31	61			72
	Number intolerant species(I)		1	0	1			1
	Number intolerant animals(I)		14	0	23			32
	Biotic index		5	3	6			11

☆ pupae are not tabulated in summary totals

Table 6. Benthic animals found in a biological survey of Marquette Bay, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species		AREA IV					
		Station:	1	2	3	4	5	6
		Depth:	20'	20'	25'	13'	15'	7'
T	Oligochaeta		30	67	34	32	71	18
T	Tubificidae				44	20	50	25
F	*Peloscolex variegatus*		16					
F	*Peloscolex ferox*		41					
T	*Limnodrilus hoffmeisteri*		51	78				
F	*Stylaria fossularis*		20	11	28	58	21	28
F	*Stylaria proboscidea*				20		39	
F	*Stylaria heringianus*				14			
T	*Tubifex tubifex*		46		32	37		
	Isopoda							
T	*Asellus militaris*		7	2		9	28	4
	Amphipoda							
I	*Pontoporeia affinis*		39	50	44	7	2	
	Gastropoda							
F	*Gyralus* sp.		2				2	
F	*Amnicola* sp.		2					
	Hirudinea							
T	*Helobdella stagnalis*						7	
F	Nematoda					11		
F	Cladocera		2	2				
	Coelenterata							
F	*Hydra* sp.		2					
	Planariidae							
F	*Dalyellia* ? sp.		4					
	Diptera							
	Tendipedidae (pupae)*					2		2
T	*Procladius adumbratus*		35	20	4	25	12	
T	*Prodiamesa bathyphila*		18	21	12	16	2	
I	*Diamesa campestris*						20	
F	*Metriocnemus lundbecki*			16				
F	*Psectrocladius simulans*					2		
F	*Psectrocladius* sp.		20		37			
F	*Cricotopus fugax*						14	
F	*Glyptotendipes senilis*					2		
F	*Polypedilum flavus*		4			2		
F	*Cryptochironomus digitatus*			4				
	Number species present		17	10	10	12	12	4
	Number of organisms/sq. ft.		339	271	269	221	268	75
	Number tolerant species(T)		6	5	5	6	6	3
	Number tolerant animals(T)		187	188	126	139	170	47
	Number facultative species(F)		10	4	4	5	4	1
	Number facultative animals(F		113	33	99	75	76	28
	Number intolerant species(I)		1	1	1	1	2	0
	Number intolerant animals(I)		39	50	44	7	22	0
	Biotic Index		12	6	6	7	8	1

* pupae are not tabulated in summary totals

Table 7. Benthic animals found in a biological survey of Marquette Bay, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species	Station: Depth:	AREA V 1 15'	2 15'	3 16'	4 25'	5 35'	6 25'	7 36'
T	Oligochaeta		28	27	12	48	21		16
T	Tubificidae					62	18		20
T	*Tubifex tubifex*		34	58			39		27
F	*Styloria fossularis*			37		166	101	97	57
	Isopoda								
T	*Asellus militaris*								5
	Planariidae								
F	*Dalyellia* sp.					2		2	
	Amphipoda								
I	*Pontoporeia affinis*		5	2	2	83	55	21	60
	Mysidacea								
I	*Mysis relicta*						2		
	Diptera								
	Tendipedidae (pupae)*		5	4			7	2	
T	*Procladius adumbratus*			2		4	2		2
T	*Prodiamesa bathyphila*		2		9	9		2	5
I	*Diamesa campestris*			7				2	
F	*Metriocnemus lundbecki*						25	7	94
F	*Psectrocladius simulans*					12		2	
F	*Psectrocladius* sp		12	23	2	11	18	5	5
F	*Calopsectra bausei*							2	
F	*Calopsectra dives*				4				
F	*Polypedilum flavus*		11	2			2	4	
F	*Harnischia nais*		5		7				
F	*Cryptochironomus digitatus*						7	2	
	Pelecypoda								
T	*Pisidium* sp.					9	12		2
	Number species present		7	8	6	10	12	11	11
	Number animals/sq. ft.		97	158	36	406	302	146	302
	Number tolerant species(T)		3	3	2	5	5	1	7
	Number tolerant animals(T)		64	87	21	132	92	2	77
	Number facultative species(F)		3	3	3	4	5	8	3
	Number facultative animals(F)		28	62	13	191	153	121	156
	Number intolerant species(I)		1	2	1	1	2	2	1
	Number intolerant animals(I)		5	9	2	81	57	23	60
	Biot'c index		5	7	5	6	9	12	5

* pupae are not tabulated in summary totals

Table 8. Benthic animals found in a biological survey of Marquette Bay, Marquette County, Michigan, August 8-11, 1968.

Tolerance Status	Species	Station: / Depth:	1 / 5'	2 / 10'	3 / 10'	4 / 15'	5 / 15'	6 / 15'	7 / 26'	8 / 26'	9 / 26'	12 / 35'
			AREA VI									
T	Oligochaeta		16	5	2	5	16	14	14	14	9	9
T	Tubificidae					4						
T	*Tubifex tubifex*		12									
F	*Stylaria fossularis*				4	4			11	23	11	22
F	*Peloscolex ferox*				4							
F	Cladocera											2
	Isopoda											
T	*Asellus militaris*								2			
F	Nematoda						2	4				2
	Amphipoda											
I	*Pontoporeia affinis*		2			7	4	2	11	5	4	12
	Diptera											
	Tendipedidae (pupae)**			5	9	12	11	5	11	9	11	5
T	*Procladius adumbratus*				2						2	
T	*Prodiamesa olivacea*										2	
T	*Prodiamesa bathyphila*			5	2					2		
I	*Diamesa campestris*							4				
F	*Metriocnemus lundbecki*							4	14	4		
F	*Psectrocladius simulans*				21							
F	*Psectrocladius* sp.			9		21	25		9			2
F	*Cricotopus fuscus*			11								
F	*Cricotopus*		12							5		
F	*Calopsectra baueri*			9								3
F	*Calopsectra dives*										12	
F	*Calopsectra* sp.									2		
F	*Limnochironomus* sp.							4				
F	*Tanytarsus obediens*											9
F	*Tanytarsus* sp.		27		11		4		21	2	2	
F	*Glyptotendipes polytomus*		2									
F	*Polypedilum flavus*		9			9	4	4	2	16	12	
F	*Polypedilum* sp.		12	4								
F	*Microtendipes tarsalis*				2							
F	*Harnischia nais*						25	7	9			
F	*Harnischia* sp. 3 (Roback)			2								
F	*Harnischia* sp.										2	
F	*Cryptochironomus demeijeri*			5								
F	*Cryptochironomus digitatus*									2	16	
F	*Cryptochironomus* sp. 4 (Curry)											2
T	*Tendipes riparius*		42	23	71	2	7			4		
T	*Tendipes anthracinus*		27					20				
	Number species present		10	9	9	7	8	9	9	11	10	9
	Number of organisms/sq. ft.		161	73	119	52	87	63	93	79	72	67
	Number tolerant species(T)		4	3	4	3	2	2	2	3	3	1
	Number tolerant animals(T)		97	33	77	11	23	34	16	20	13	9
	Number facultative species(F)		5	6	5	3	5	5	6	7	6	7
	Number facultative animals(F)		62	40	42	34	60	23	66	54	55	46
	Number intolerant species(I)		1	0	0	1	1	2	1	1	1	1
	Number intolerant animals(I)		2	0	0	7	4	6	11	5	4	12
	Biotic index		7	6	5	5	7	9	8	9	8	9

** pupae are not tabulated in summary totals

Table 9. Benthic animals found in a biological survey of Marquette Bay, Marquette County, Michigan, August 8-11, 1968.

			A R E A VII						
Tolerance Status	Species	Station:	1	2	3	4	5	6	7
		Depth:	14'	15'	15'	24'	25'	25'	35
T	Oligochaeta		2	2		18		5	[illegible]
T	Tubificidae								
F	*Stylaria fossularis*			9				11	21
T	*Limnodrilus hoffmeisteri*					9			
F	Nematoda							4	3
	Amphipoda								
I	*Pontoporeia affinis*					1	4		9
	Diptera								
F	*Bezzia* sp.							4	
	Tendipedidae (pupae)*		2	11	5	9	4	14	
T	*Prodiamesa olivacea*					2			
F	*Metriocnemus lundbecki*		16			11	11		11
F	*Psectrocladius simulans*		9	4				16	2
F	*Psectrocladius* sp.								
F	*Calopsectra* sp.			11					
F	*Tanytarsus obediens*						16		
F	*Tanytarsus* sp.				11				
F	*Polypedilum flavus*					12		18	
F	*Harnischia nais*						2		
T	*Tendipes riparius*		4	11	7	5		2	
	Number species present		4	5	2	7	4	7	6
	Number of organisms/sq. ft.		31	37	18	60	33	60	63
	Number tolerant species(T)		2	2	1	4	0	2	1
	Number tolerant animals(T)		6	11	7	36	0	7	18
	Number facultative species(F)		2	3	1	2	3	5	4
	Number facultative species(F)		25	24	11	23	29	53	36
	Number intolerant species(I)		0	0	0	1	1	0	[illegible]
	Number intolerant animals(I)		0	0	0	1	4	0	9
	Biotic index		2	3	1	4	5	5	6

* pupae are not tabulated in summary totals

Table 13. Attached and plankton algae composition from thirteen locations near shore in Lake Superior, Vicinity of Marquette, August 8-11, 1968

Station Number	Type of sample (Method of collecting)	Attached Algae																				Planktonic Algae															
		Oscillatoria	Phormidium	Tolypothrix	Spirogyra	Cymbella	Tabellaria	Fragilaria	Navicula	Stigeoclonium	Melosira	Euastrum	Cyclotella	Diatoma	Gomphonema	Asterionella	Synedra	Dinobryon	Ulothrix	Cladophora	Anacystis	Asterionella	Dinobryon	Tabellaria	Staurastrum	Synedra	Fragilaria	Cymbella	Melosira	Spirogyra	Cladophora	Entophysalis	Gomphonema	Diatoma	Navicula	Cyclotella	S.B Count/ml
1	Attached algae from pilings and concrete slabs				x	x	x	x	x	x*	x									x																	
2	Attached algae from rocks along shore-line					x	x	x		x		x	x	x	x																						
3	Attached algae from rocks along shore-line						x	x	x		x					x	x	x																			
4	Net plankton (3 min tow)																					x	x	x	x	x	x	x	x								
5	Attached algae from rocks and break-water					x	x	x	x		x					x			x																		
6	Attached algae from pilings					x		x											x																		
7	Grab sample near shore																										x										35
8	Grab sample near shore																									x	x			x	x	x	x	x	x		17
9	Attached algae from rock scrapings also grab sample			x			x		x		x						x		x		x														x		35
10	Attached algae from rocks, grab sample near shore	x	x			x			x		x				x						x			x					x						x		140
11	Attached algae from rocks, grab sample near shore																			x				x			x	x	x				x	x	x		
12	Grab sample near shore																																x				105
13	Attached algae from pilings, grab sample near shore						x	x	x				x						x																	x	70

Table 11. Phenolic concentrations at selected stations in Presque Isle Harbor, Marquette County, Michigan, August 8, 1968.

	Phenolic concentrations in ppb.										
Station No.	1	2	3	4	5	6	7	8	9	10	11
Surface	0	6	4	10	10	12	4	0	4	4	4
Bottom	0	0	0	0	0	0	0	0	4	4	4
Maximum depth	38'	38'	25'	34'	34'	33'	44'	49'	49'	43'	68'

APPENDIX Q-B

Figure 1. Number of species according to their tolerance status found in quantitative samples from Lake Superior, vicinity of Marquette, Michigan, August 8-11, 1968.

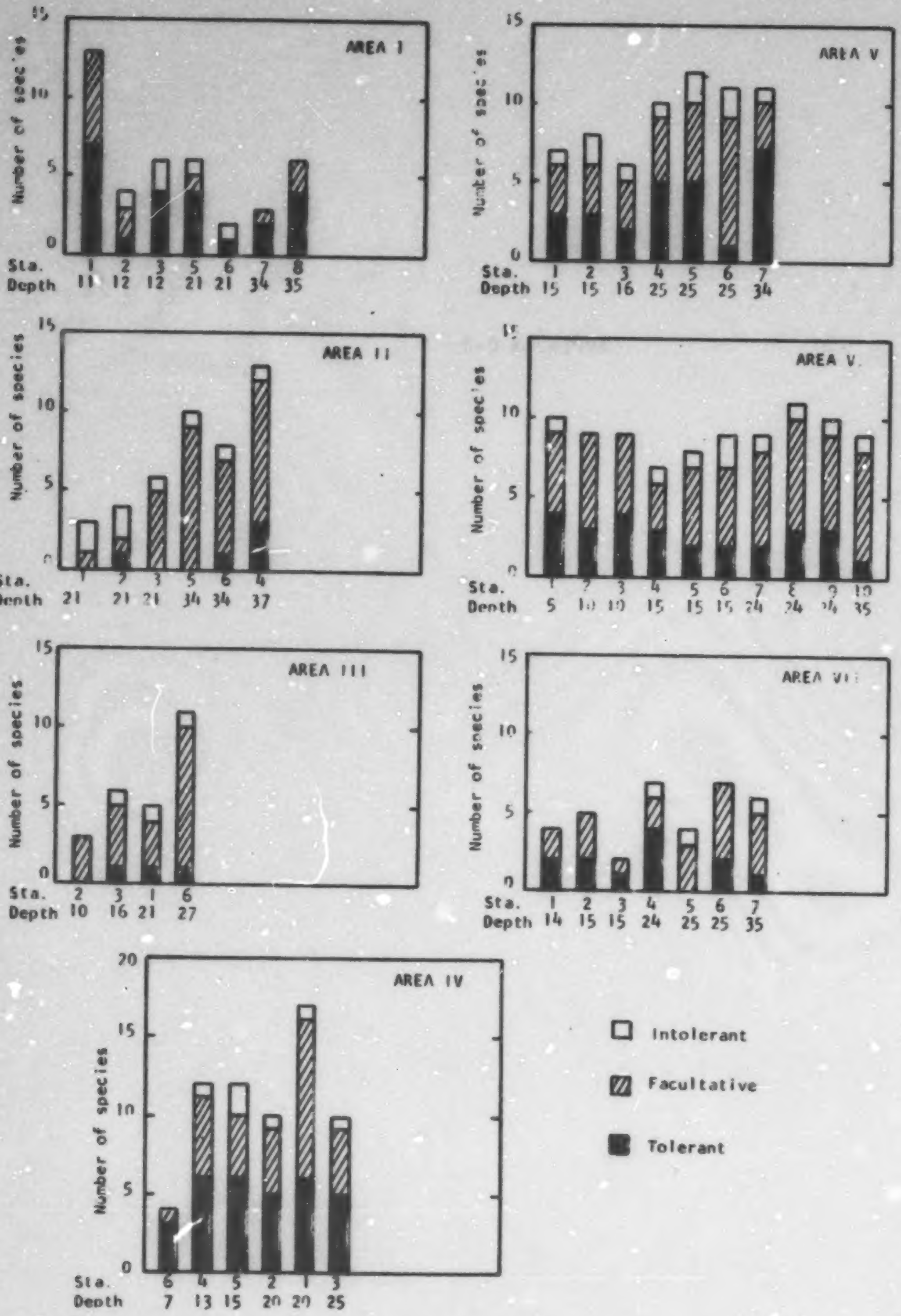
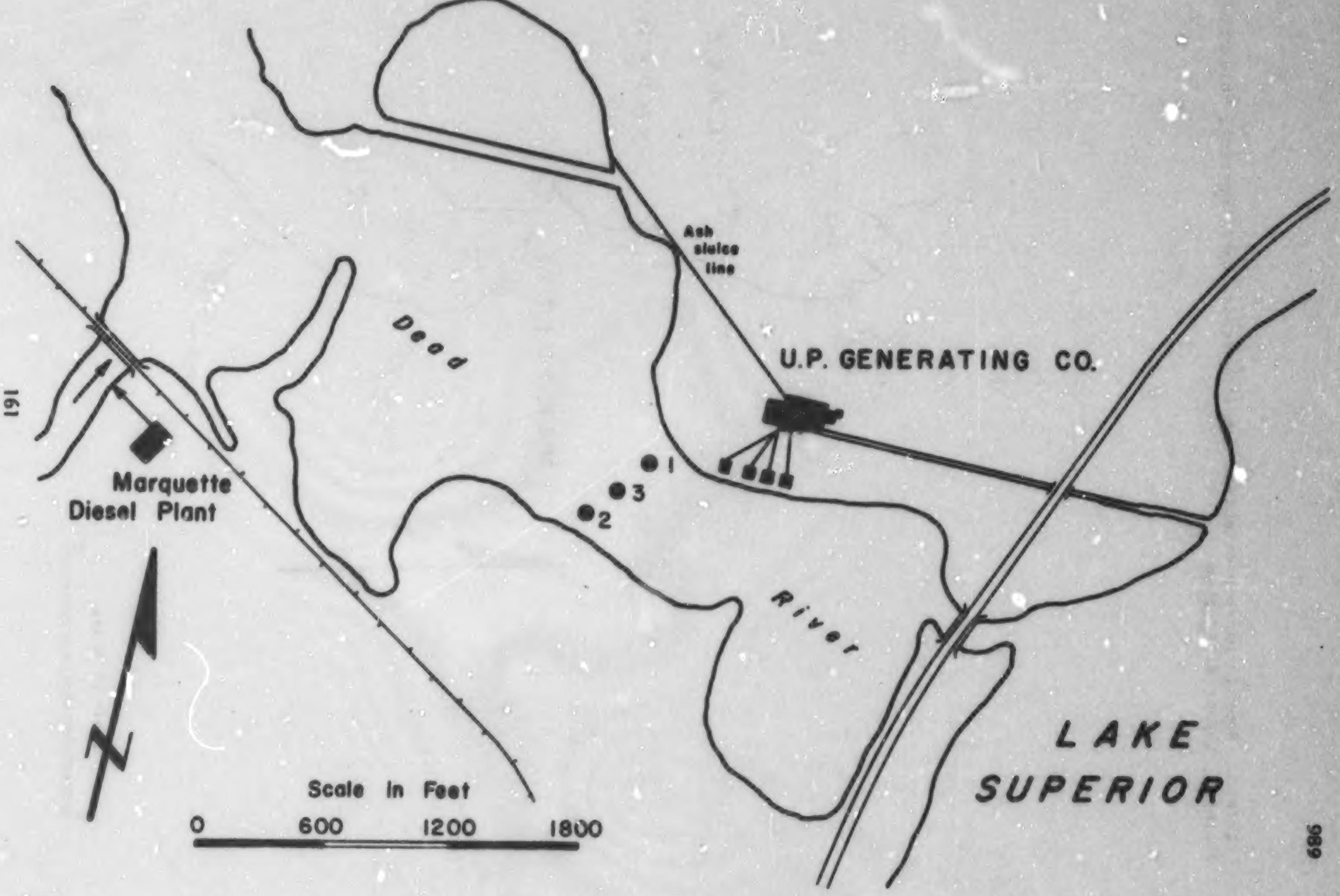
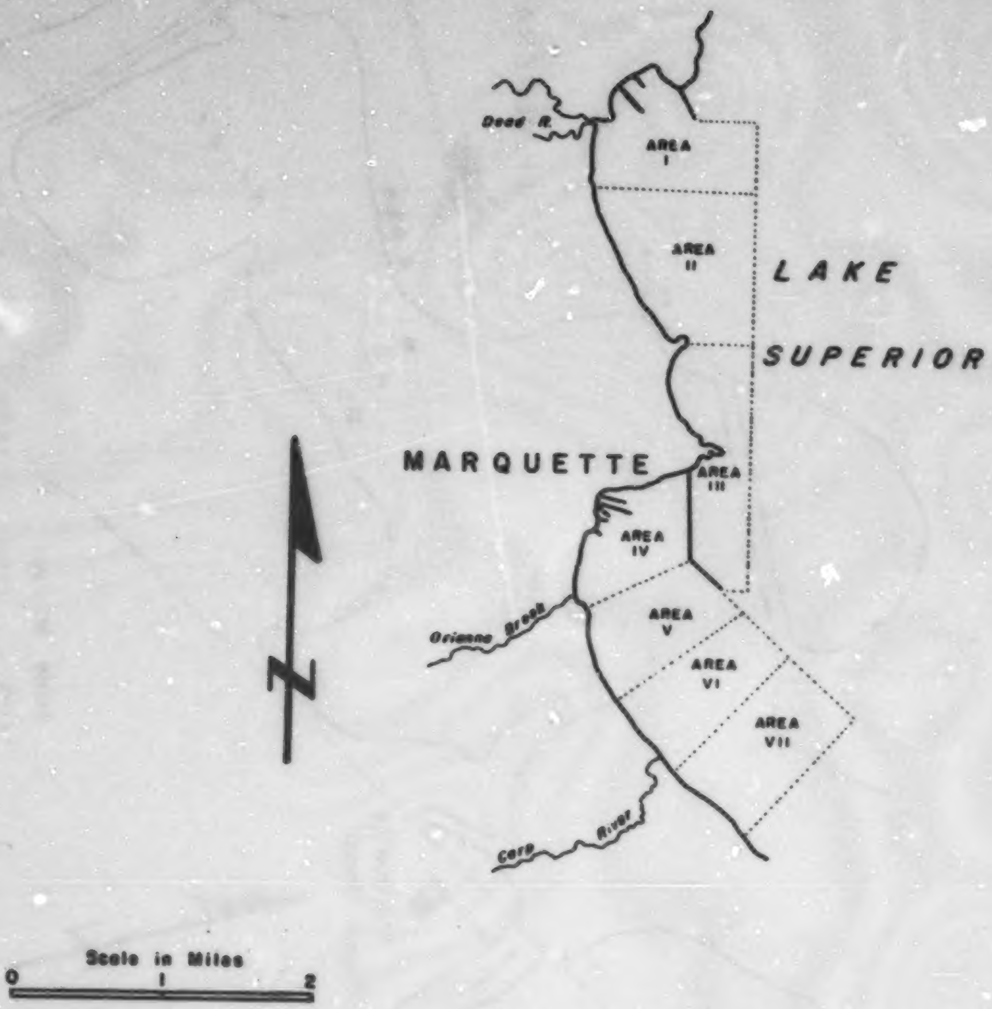


Figure 2. Qualitative biological sampling stations in the Dead River, Marquette County, Michigan, August 8-11, 1968.

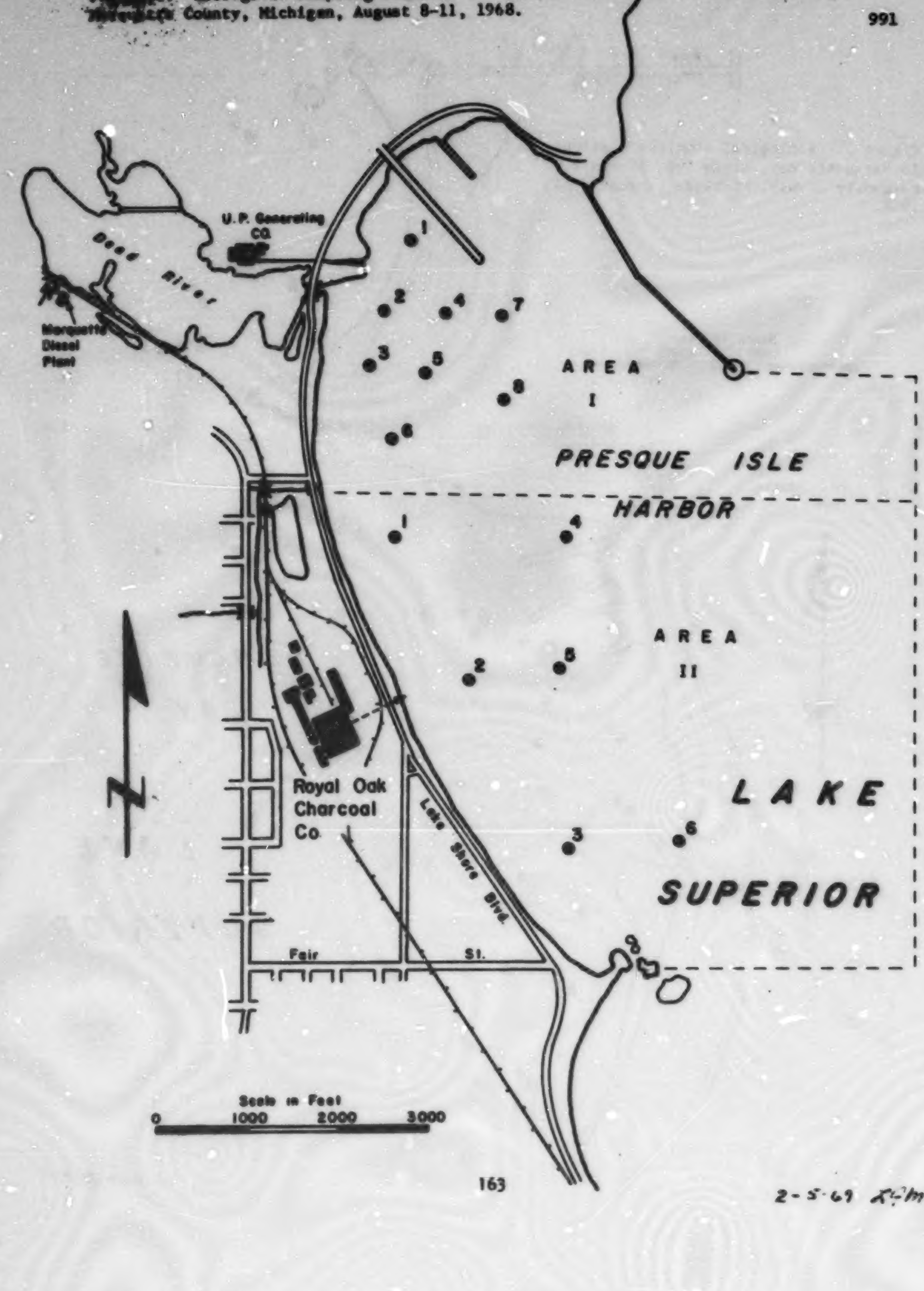

U.P. GENERATING CO.
Ash sluice line
Dead
River
LAKE SUPERIOR
1
3
2
Marquette Diesel Plant
Scale in Feet
0
600
1200
1800

2-7-69 4.9 mil

Figure 3. Benthic macroinvertebrate sampling areas, Lake Superior, Marquette vicinity, August 8-11, 1968.

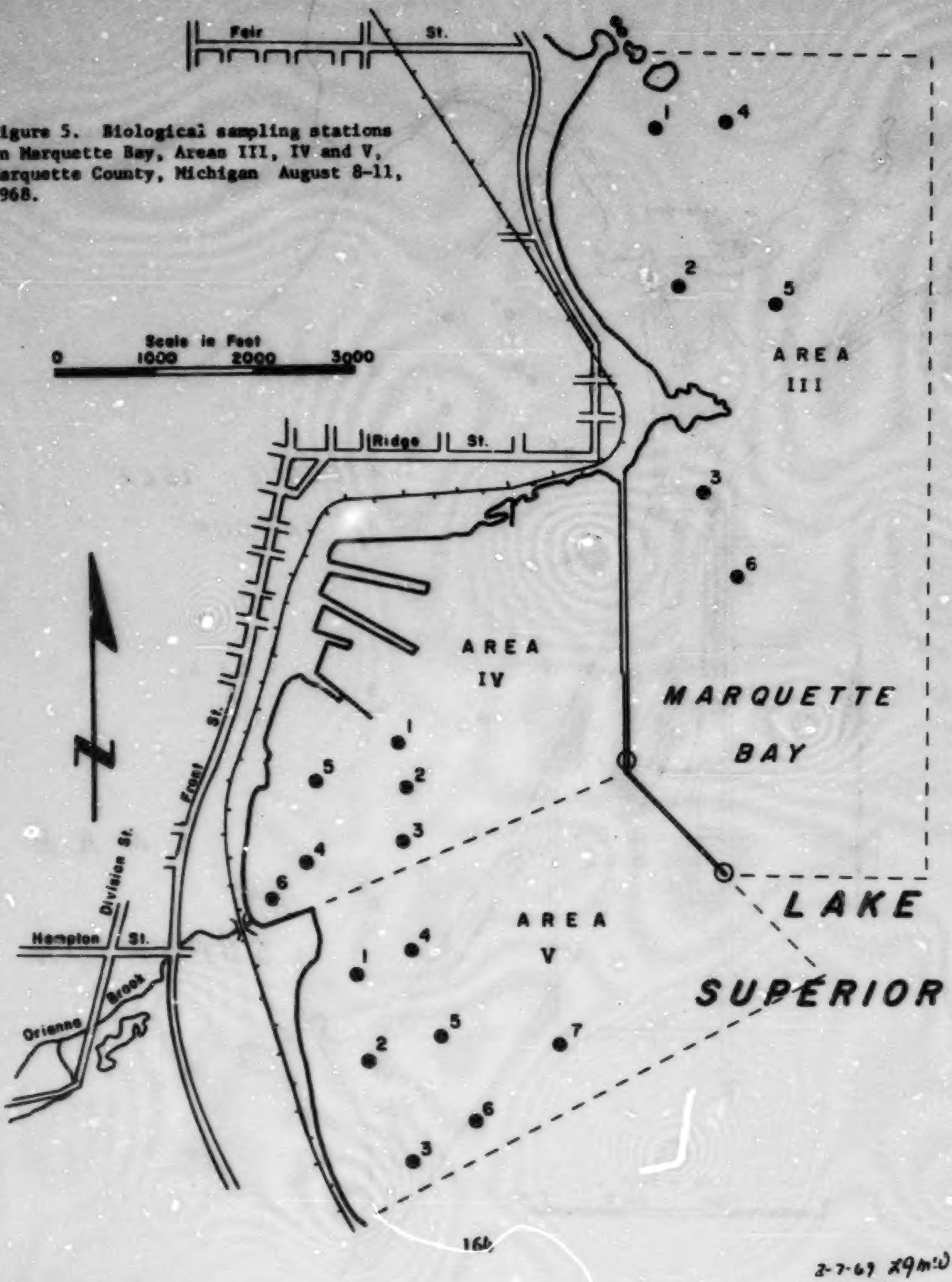

Dead R.
AREA I
AREA II
LAKE SUPERIOR
MARQUETTE
AREA III
AREA IV
AREA V
AREA VI
AREA VII
Orianna Brook
Carp River
Scale in Miles
0
1
2

[illegible]. Biological sampling stations in Presque Isle Harbor, Areas I and II, Marquette County, Michigan, August 8-11, 1968.


U.P. Generating Co.
Dead River
Marquette Diesel Plant
AREA I
PRESQUE ISLE HARBOR
AREA II
LAKE SUPERIOR
Royal Oak Charcoal Co.
Lake Shore Blvd.
Fair St.
1
2
3
4
5
6
7
8
Scale in Feet
0
1000
2000
3000

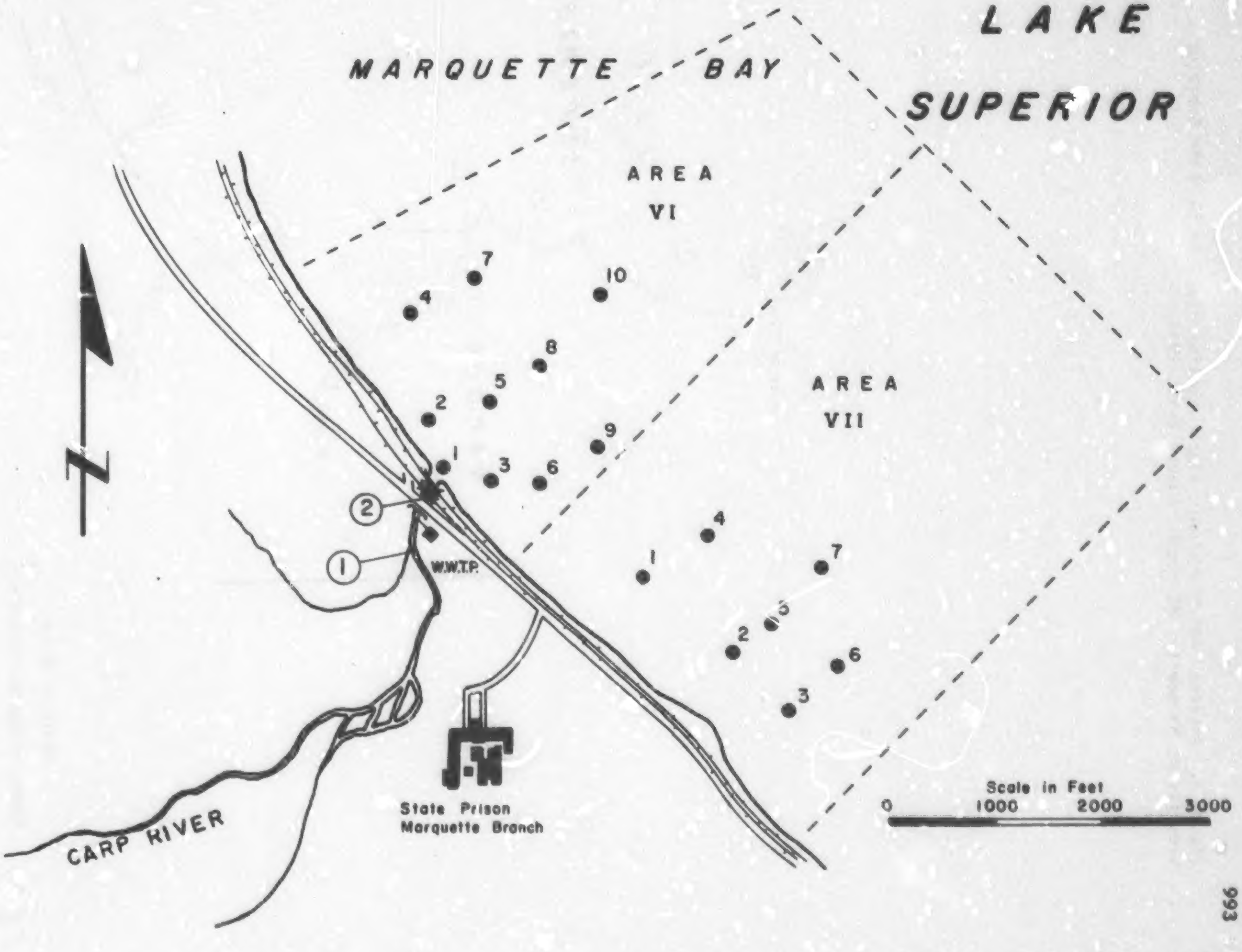
2-5-69 [illegible]

Figure 5. Biological sampling stations in Marquette Bay, Areas III, IV and V, Marquette County, Michigan August 8-11, 1968.


Fair St.
Ridge St.
Front St.
Division St.
Hampton St.
Orienne Brook
Scale in Feet
0
1000
2000
3000
AREA III
AREA IV
AREA V
MARQUETTE BAY
LAKE SUPERIOR
1
2
3
4
5
6
7

2-7-69 Z9m:D

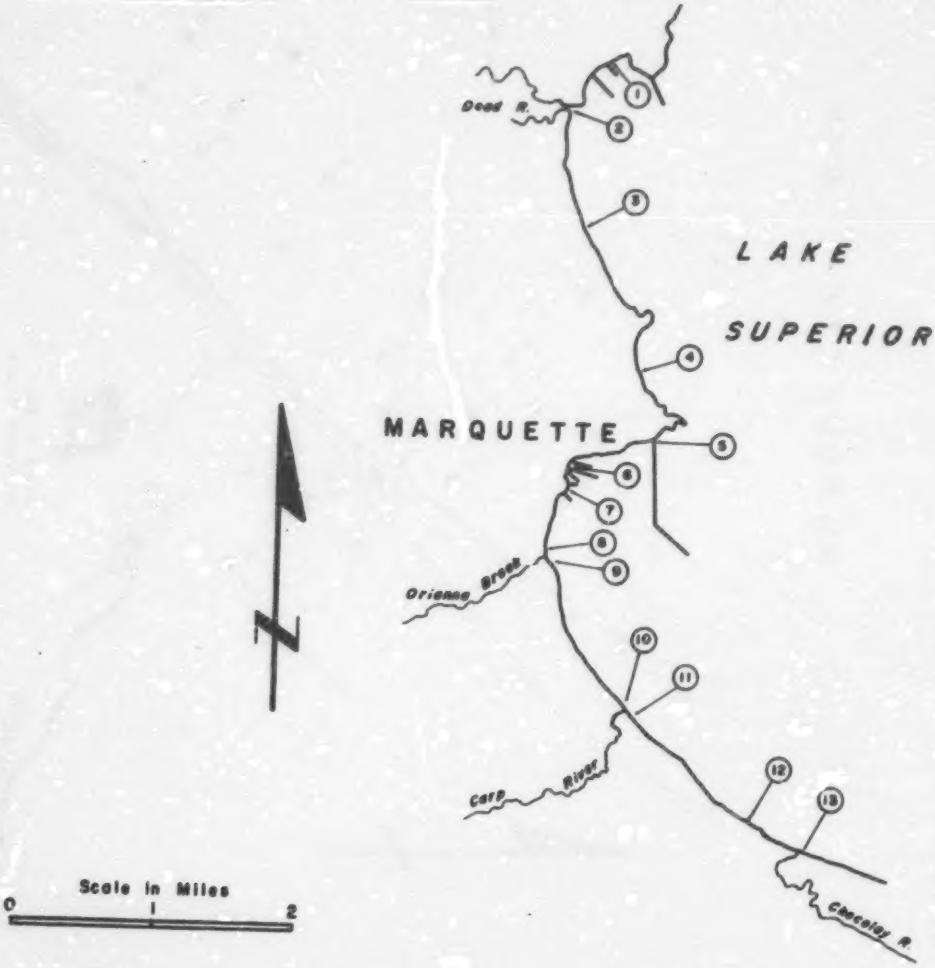
Figure 6. Biological sampling stations in Marquette Bay, Areas VI and VII and the Carp River, Marquette County, Michigan, August 8-11, 1968.


LAKE SUPERIOR
MARQUETTE BAY
AREA VI
AREA VII
4
7
10
8
2
5
9
1
3
6
1
4
7
2
5
6
3
②
①
W.W.T.P.
State Prison
Marquette Branch
CARP RIVER
Scale in Feet
0
1000
2000
3000

993

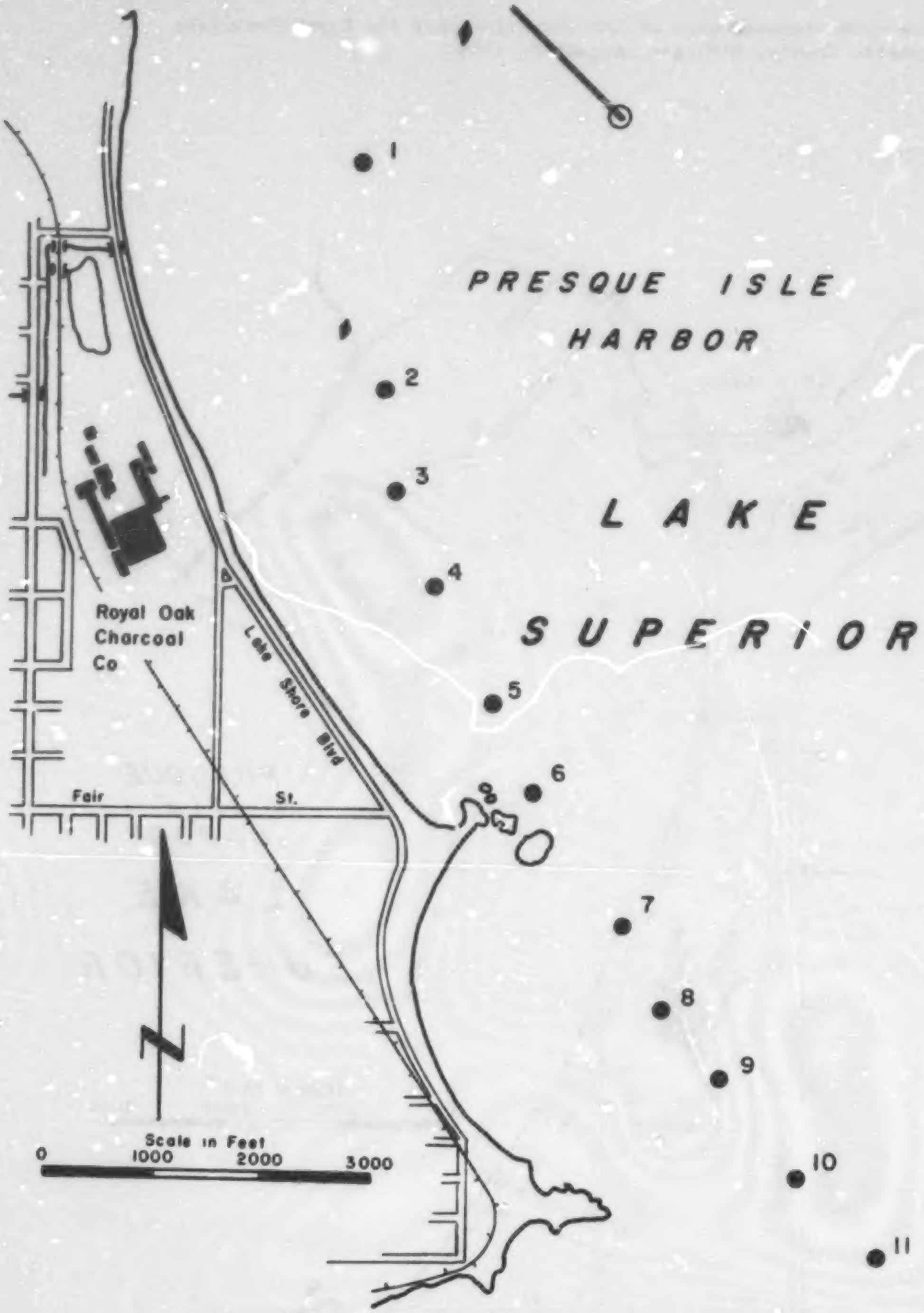
2-7-69 Z9m:

Figure 7. Attached and planktonic algae sampling stations in Lake Superior, vicinity of Marquette, Michigan, August 8-11, 1968.


Dead R.
1
2
3
LAKE SUPERIOR
4
MARQUETTE
5
6
7
8
9
Orianna Brook
10
11
Carp River
12
13
Chocolay R.
Scale in Miles
0
1
2

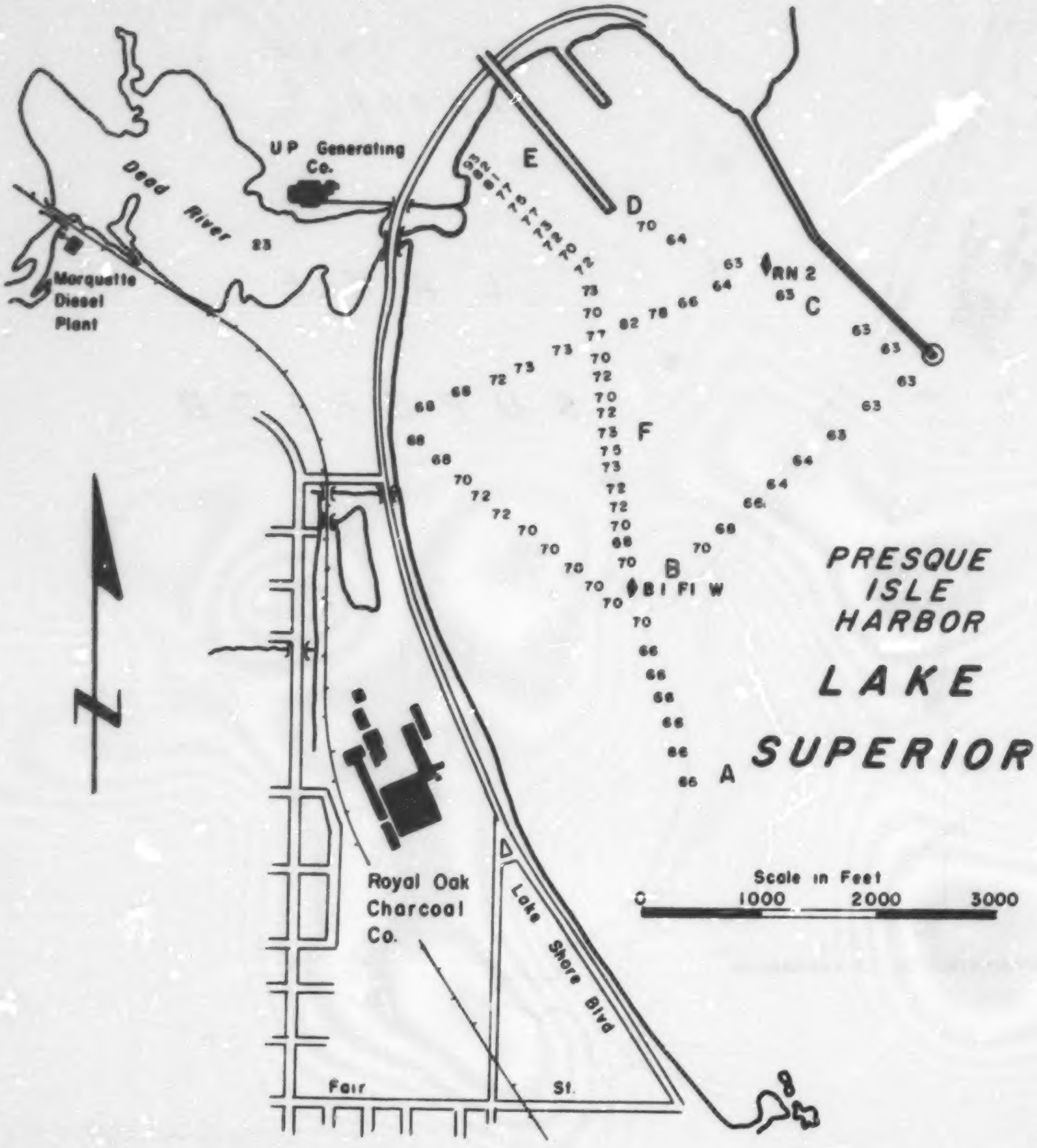
3-17-69

Figure 8. Location of phenolic sampling stations in Lake Superior, Marquette County, Michigan, August 8-11, 1968.


PRESQUE ISLE HARBOR
LAKE SUPERIOR
Royal Oak Charcoal Co
Lake Shore Blvd
Fair St.
1
2
3
4
5
6
7
8
9
10
11
Scale in Feet
0
1000
2000
3000

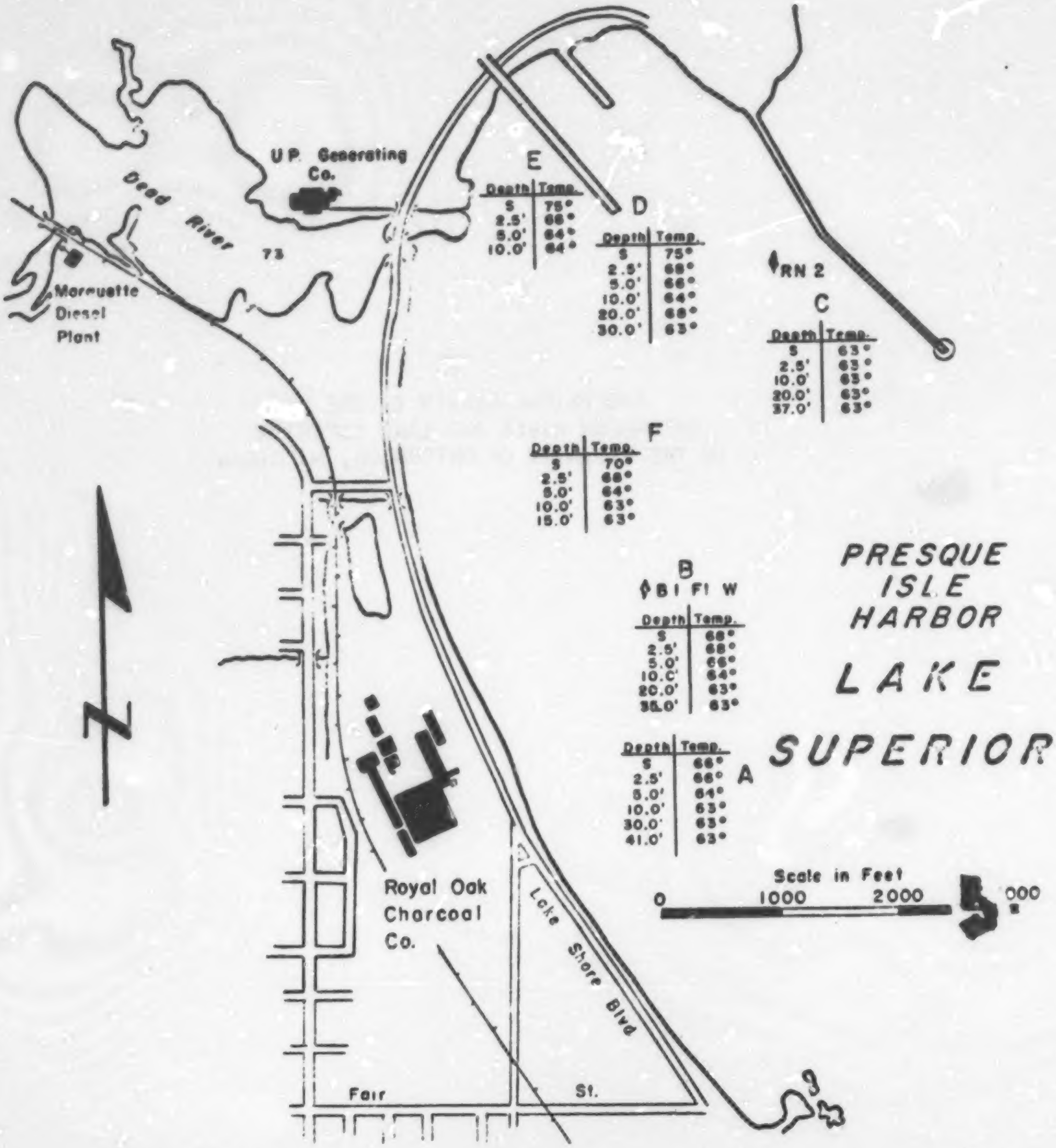
2-12-69 I9m'O.

Figure 9. Surface water temperatures of Lake Superior near the Upper Peninsula Power Plant, Marquette County, Michigan, August 8, 1968.


U P Generating Co.
Dead River
83
Marquette Diesel Plant
E
D
RN 2
C
F
B
B I Fl W
A
PRESQUE ISLE HARBOR
LAKE SUPERIOR
Scale in Feet
0
1000
2000
3000
Royal Oak Charcoal Co.
Lake Shore Blvd
Fair
St.

2-7-69 ZJm:D

Figure 10. Water temperature depth profiles in Lake Superior near the Upper Peninsula Power Plant, Marquette, Michigan, August 8, 1968. (Temperature in °F and depth in feet. S refers to surface temperatures)


U.P. Generating Co.
Dead River
73
Marquette Diesel Plant
E
D
RN 2
C
F
B
B I Fl W
A
PRESQUE ISLE HARBOR
LAKE SUPERIOR
Scale in Feet
0
1000
2000
3000
Royal Oak Charcoal Co.
Lake Shore Blvd
Fair St.

E

Depth	Temp.
S	75°
2.5'	66°
5.0'	64°
10.0'	64°

D

Depth	Temp.
S	75°
2.5'	68°
5.0'	66°
10.0'	64°
20.0'	68°
30.0'	63°

C

Depth	Temp.
S	63°
2.5'	63°
10.0'	63°
20.0'	63°
37.0'	63°

F

Depth	Temp.
S	70°
2.5'	68°
5.0'	64°
10.0'	63°
15.0'	63°

B

Depth	Temp.
S	68°
2.5'	68°
5.0'	66°
10.C'	64°
20.0'	63°
30.0'	63°

A

Depth	Temp.
S	66°
2.5'	66°
5.0'	64°
10.0'	63°
30.0'	63°
41.0'	63°

?-7-69

APPENDIX R

BIOLOGICAL SURVEY OF THE ONTONAGON RIVER AND LAKE SUPERIOR IN THE VICINITY OF ONTONAGON, MICHIGAN

MICHIGAN WATER RESOURCES COMMISSION

Biological Survey of the Ontonagon River and Lake Superior, in the Vicinity of Ontonagon, Michigan

August 15, 1968

On August 15, 1968 a biological survey was conducted on the Ontonagon River and Lake Superior in the vicinity of Ontonagon, Michigan. The Hoerner-Waldorf Corporation paper mill and the Ontonagon Wastewater Treatment Plant (WWTP) effluents provide the major sources of influence on the waters of this area.

MACROFAUNA SURVEY

Methods

Quantitative collections of bottom-dwelling macroinvertebrates were made by single Ponar dredge hauls at each river and lake station (Figure 1). A U.S. Standard #30 - mesh bucket sieve was used for sieving the samples which were then preserved with formalin and labeled. Organisms were washed, sorted, identified, and tabulated in the Lansing laboratory. Animals were assigned a tolerance status according to published accounts and the past experience of the biology staff of the Michigan Water Resources Commission (Table 1).

Tolerance status may be generally defined as:

Tolerant - organisms that can grow and develop within a wide range of environmental conditions. They are often found in water of poor quality. These species are generally insensitive to a variety of environmental stresses.

Intolerant - organisms whose growth and development are dependent upon a narrow range of optimum environmental conditions. They are rarely found in areas of organic enrichment. They cannot adapt to adverse situations and are replaced by less sensitive organisms if the quality of their environment is degraded.

Facultative - organisms with the ability to survive over a wide range of conditions. They possess "medium" tolerance and often respond positively to moderate organic enrichment but cannot tolerate severe environmental stresses.

In addition to tolerance status, the diversity of animals in a given benthic community is significant. In general, pollutional communities are characterized by very low species diversity, while normal undisturbed communities contain many different species.

Biological Observations

Locations of the seventeen sampling stations are shown in Figure 1. In order to facilitate interpretation of the macroinvertebrate findings of this survey, the benthic sampling stations have been divided into lake and river stations. A condensation of the biological data is listed in Table 1. Figure 2 graphically portrays the total number of species collected as well as the number of species in each of the tolerance groups (intolerant, facultative, and tolerant) for each station.

Ontonagon River Stations 10, 11, 12, 13, 14, 15, 16

The Ontonagon River carries a heavy load of naturally introduced suspended solids which consist mainly of red clay particles. This natural turbidity results in very low water transparency. During this study river transparencies, measured by Secchi disk, ranged from 1.0 to 1.5 feet.

Bottom fauna collections were taken in the Ontonagon River from a point 1,000 feet above the Ontonagon WWTP discharge to a point 200 feet above the lake end of the breakwater. Bottom deposits were sand, red clay, and organic detritus at all stations except station 11 where the sediments were woody fibers and black muck. When the deposits at station 11 were disturbed they emitted gas bubbles and oil. These deposits were found only in the small bay-like area in front of the Hoerner-Waldorf Corporation paper mill discharge ditch. Stations 10 through 16 were sampled at 4 to 16 foot depths. Dominant animals were midges, oligochaetes and mayflies. The range in number of species was 5-9 while the range in number of animals per square foot was 24-208. The above figures do not include the findings at station 11 where no animals were present.

The Ontonagon WWTP outfall did not appear to have any appreciable effect upon the downstream aquatic communities. An increase in sludgeworms at station 12 (127/ sq. ft.) was indicative of some enrichment. However, a balanced benthic fauna, including sensitive mayflies, was found at stations 15 and 12, which were 150 and 1200 feet below the outfall, respectively.

Station 13R, off the mouth of the small diversion channel along the right bank, also contained larger numbers of sludgeworms (172/sq. ft.). This may indicate some source of organic enrichment entering the river at this location.

Station 10 is unique in this survey in that it is characteristic of both lake and river. The colder Lake Superior water extends up the breakwater channel while the warmer river water passes downstream overhead. The fauna is most characteristic of the upstream river, containing riffle beetles, mayflies, and similar midge species. However, the intolerant lake scud Pontoporeia affinis was also found at this location. This was the most diverse and well balanced station found in the entire survey.

The Hoerner-Waldorf Corporation mill effluent flows out on the surface of the Ontonagon River where it is almost immediately transported down the breakwater channel to Lake Superior. The warmer effluent tends to stay near the surface and thus exerts very little effect upon the benthos of the Ontonagon River before entering the lake. This was substantiated by the clean water fauna found downstream at station 10.

Lake Superior - Stations 1-9

By observing the discolored Ontonagon River plume it was apparent that considerable quantities of red clay are transported to Lake Superior. Secchi disk transparency measurements showed significant reductions of light penetration in the offshore waters. This turbidity has at least two effects upon the lake. Reduced light penetration results in a reduction of primary productivity which is already limited in Lake Superior by extremely low nutrient concentrations. These clay particles eventually settle to the bottom and alter the benthic environment.

Bottom samples from Lake Superior were separated into two areas based mainly upon bottom sediment compositions. Area 1 (stations 1, 2, 3, and 4) contained bottom sediments of clean fine to coarse sand at depths of 18 to 25 feet. Area II (stations 5, 6, 7, 8, and 9) contained bottom sediments of sand, red clay, and organic detritus (plant material) at depths of 22 to 45 feet. The red clay and organic detritus are river transport materials and indicate the area of river influence on Lake Superior benthos in the offshore vicinity of the Ontonagon River mouth. Completely different benthic faunas inhabited these areas as indicated by summary data provided in Table 2.

Area I - stations 1, 2, 3, and 4

Productivity in this area was extremely low with an average of only 19 animals per square foot of substrate. Facultative midges were dominant, with Chironomus sp. B and Colopsectra dives predominant. The intolerant scud Pontoporeia affinis was found at two stations. Tolerant sludgeworms were found only at station 2. The clean sand substrate of this area offers very little food for maintaining benthic animal life.

Area II - stations 5, 6, 7, 8, and 9

The bottom fauna composition found in this area was in sharp contrast to that of area I. The average number of animals per square foot of substrate was 62, more than three times that of area I. Tolerant sludgeworms dominated this community. The midges Polypedilum, Metriocnemus lundbecki, and Tendipes riparius were also numerous. Intolerant species were absent from all stations.

The red clay, organic detritus and other river associated materials settling to the bottom have enriched this area. The scope of this enrichment does not appear to be extensive. However, the decomposing organic material may exert a considerable effect at the substrate-water interface, but this was not studied. Organic materials as settleable solids arising from the Ontonagon WWTP and Hoerner-Waldorf paper mill may add somewhat to this condition, but the decomposing plant materials were the largest factor.

Summary

1. On August 15, 1968 a biological survey was conducted on the Ontonagon River and Lake Superior in the vicinity of Ontonagon, Michigan.

2. The two major sources of waste discharge to the Ontonagon River were the Hoerner-Waldorf Corporation paper mill and the Ontonagon Wastewater Treatment Plant.

3. The Ontonagon River carries a heavy load of naturally introduced suspended soils which consist mainly of red clay particles. This natural turbidity results in very low water transparency. During this study river transparency measured by Secchi disk ranged from 1.0 to 1.5 feet.

4. Bottom deposits in the Ontonagon River were sand, red clay, and organic plant detritus at all stations except station 11 where the sediments were woody fibers and black muck containing considerable oils and gas.

5. The Ontonagon WWTP outfall did not appear to have any appreciable effect upon the downstream aquatic communities. An increase in sludgeworms at station 12 (127/sq. ft.) was indicative of some enrichment. However, a balanced benthic fauna, including sensitive mayflies, was found at stations 15 and 12, which were 150 and 1200 feet below the outfall, respectively.

6. The Hoerner-Waldorf Corporation mill effluent flows out on the surface of the Ontonagon River where it is almost immediately transported down the breakwater channel to Lake Superior. The warmer effluent tends to stay near the surface and thus exerts very little effect upon the benthos of the Ontonagon River before entering the lake. This was substantiated by the clean water fauna found downstream at station 10.

7. By observing the discolored Ontonagon River plume it was apparent that considerable quantities of red clay are transported to Lake Superior. Secchi disk transparency measurements showed significant reductions of light penetration in the offshore waters.

8. Benthic stations from Lake Superior were separated into two areas based mainly upon bottom sediment composition. Area I contained bottom sediments of clean fine to coarse sand in contrast to area II which contained bottom sediments of sand, red clay, and organic detritus (Plant material).

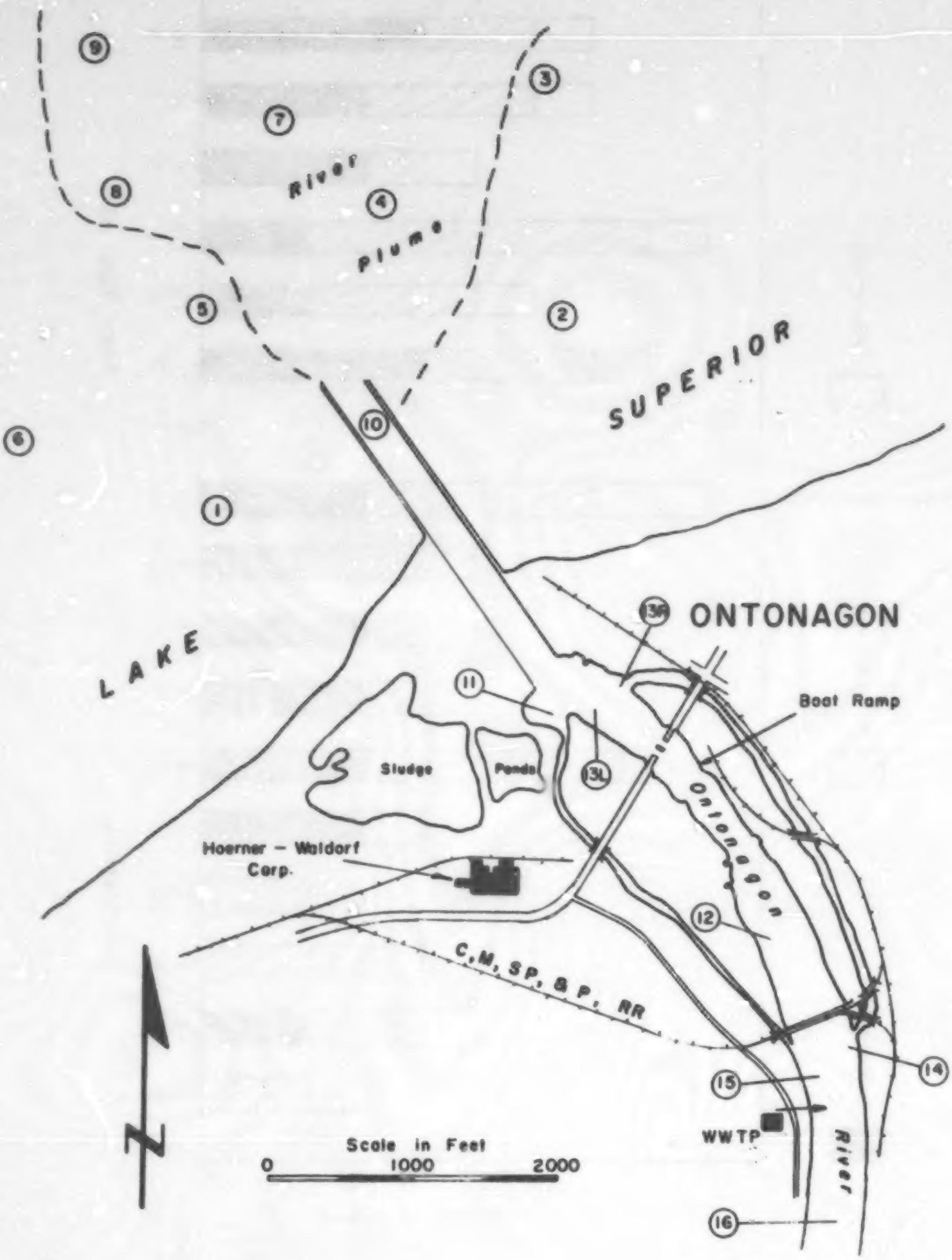
9. Productivity in area I was extremely low with an average of only 19 animals per square foot. Facultative midge larvae were the dominant animals. The bottom fauna composition found in area II was in sharp contrast to that of area I. The average number of animals per square foot of substrate was 62, more than three times that of area I. Tolerant sludgworms dominated the benthic community in area II.

10. The red clay, organic detritus and other river associated materials settling to the bottom have enriched area II. The scope of this enrichment did not appear to be extensive. Organic materials, as settleable solids, arising from the Ontonagon WWTP and Hoerner-Waldorf paper mill may add somewhat to this condition, but the decomposing plant materials were the largest factor.

Field and Laboratory work supervised by:	D. James Seeburger, Aquatic Biologist
Report by:	D. James Seeburger Water Quality Appraisal Unit WATER RESOURCES COMMISSION Michigan Department of Natural Resources

jeh
March 1969

Figure 1. Bottom fauna sampling stations in the Ontonagon vicinity, August 15, 1968.


⑨
③
⑦
River
⑧
④
Plume
⑤
②
SUPERIOR
⑥
⑩
①
LAKE
13R
ONTONAGON
⑪
Boat Ramp
Sludge
Ponds
13L
Ontonagon
Hoerner – Waldorf
Corp.
⑫
C, M, SP, & P, RR
⑭
⑮
WWTP
River
Scale in Feet
0
1000
2000
⑯

2/3/69 LQmcD.

Figure 2. Number of species, according to their tolerance status, as found in quantitative samples from Lake Superior and the Ontonagon River, August 15, 1968

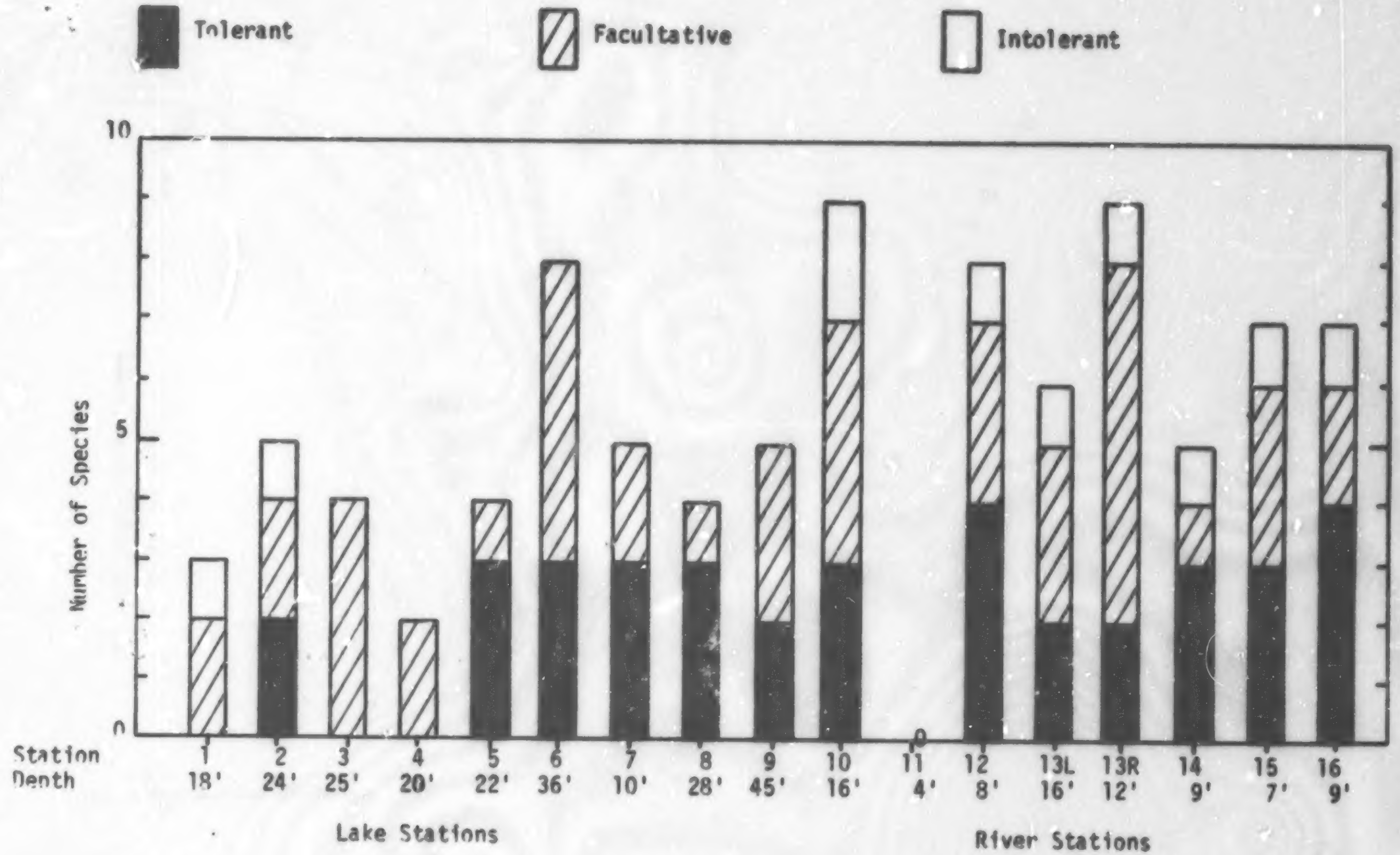


Table 1. Benthic animals found in a biological survey of the Ontonagon River and Lake Superior in the vicinity of Ontonagon, Michigan, [illegible]

Tolerance Status	Species	Lake Superior Area I 1	 2	 3	 4	 Area II 5	 6	 7	 8	 9	Ontonagon River 10	 11	 12	 13L	 [illegible]	 14	 15	 16
	Station:	1	2	3	4	5	6	7	8	9	10	11	12	13L	[illegible]	14	15	16
	Depth:	18'	24'	25'	20'	22'	36'	35'	28'	45'	16'	4'	8'	15'	[illegible]	[illegible]	7'	[illegible]
	Secchi disk :	16'	12'	15'	8'	13'	13'	10'	3'	9'	2'	0.5'	1'	1'	[illegible]	[illegible]	1	1.5'
T	Oligochaeta					19	4	11	15	5	4		21	2	25	11	14	4
T	*Limnodrilus hoffmeisteri*		12			37	2	27	41	35			92		128	16	35	4
F	*Stylaria proboscidea*						4			4								
F	*Peloscolex ferox*										7		14					
F	Naididae														9			
	Amphipoda																	
I	*Pontoporeia affinis*	12	4								2							
	Pelecypoda																	
T	Sphaeriidae																	5
	Coleoptera																	
F	*Stenelmis* sp.										2				2			
	Odonata																	
F	*Gomphus* sp.													2	2		2	
	Megaloptera																	
F	*Sialis* sp.														2		2	
	Ephemeroptera																	
F	*Caenis* sp.																	2
I	*Hexagenia limbata*										5		4	2	5	2	2	9
	Diptera																	
F	*Bezzia* sp.							2										
	Tendipedidae (pupae)*		2	4												3		
T	*Pentaneura* sp.										9							
T	*Procladius adumbratus*												5			[illegible]		
F	*Metriocnemus lundbecki*				4	2	12		19									
F	*Psectrocladius simulans*						4											
F	*Psectrocladius* sp.										9							
F	*Calopsectra dives*	2	2	11				12										
F	*Tanytarsus* sp.			2							7				7			
F	*Glyptotendipes senilis*			2														
F	*Polypedilum* sp.						19		7	7			9	11			34	
F	*Harnischia* sp.													2				
F	*Cryptochironomus digitatus*												18		18	2		
F	*Xenochironomus* sp.																	2
F	*Chironomus* sp. 8 (Joh)		5	9	5													
F	*Tendipes atroviridis*	5																
T	*Tendipes plumosus*																	
F	*Tendipes riparius*		2			2	2	9					2					
T	*Tendipes staegeri*								2									
											18			3			5	3
	Fish (Lamprey)																	
F	Petromyzontidae						2											
	Number species present	3	5	4	2	4	8	5	4	5	9	0	8	6	3	8	7	7
	Number animals per square foot	19	25	24	9	60	49	61	69	70	63	0	165	24	[illegible]	36	94	26
	Number tolerant species (T)	0	2	0	0	3	3	3	3	2	3	0	4	2	[illegible]	3	3	4
	Number tolerant animals (T)	0	14	0	0	58	8	47	62	40	31	0	120	7	[illegible]	32	44	15
	Number facultative species (F)	2	2	4	2	1	5	7	1	3	4	0	3	3	6	1	3	2
	Number facultative animals (F)	7	7	24	9	2	41	14	7	30	25	0	41	15	[illegible]	2	32	4
	Number intolerant species (T)	1	1	0	0	0	0	[illegible]	0	0	2	0	1	1	[illegible]	[illegible]	1	1
	Number intolerant animals (T)	12	4	0	0	0	[illegible]	0	0	0	7	0	4	2	[illegible]	2	1	[illegible]

* pupae are not tabulated in summary totals

Table 2. A comparison of summary biological data from the benthos of areas I and II in Lake Superior, vicinity of Ontonagon, Michigan, August 15, 1968

Parameter	Area I	Area II
Average species / station	3.5	5.2
Average tolerant species / station	0.5	2.8
Average facultative species / station	2.5	2.4
Average intolerant species / station	0.5	0.0
Average animals / station	19.2	61.8
Average tolerant animals / station	3.5	43.0
Average facultative animals / station	11.7	18.8
Average intolerant animals / station	4.0	0.0

APPENDIX S

BIOLOGICAL SURVEY OF THE FREDA COPPER MILL DISCHARGE TO LAKE SUPERIOR IN THE VICINITY OF FREDA, MICHIGAN

MICHIGAN WATER RESOURCES COMMISSION

Biological Reconnaissance Survey of the Freda Copper Mill Discharge to Lake Superior in the Vicinity of Freda, Michigan

August 24th and 27th, 1966

This survey was conducted at the request of Mr. Joseph Bal, District Engineer, Michigan Water Resources Commission. The objectives of this investigation were 1) to determine the effects of the Freda Copper Mill tailings discharge on the benthic fauna of Lake Superior, and 2) to determine the extent of the discoloration caused by the tailing wastes.

Methods

Eight quantitative macroinvertebrate bottom fauna samples were collected with a Ponar dredge (Figure 1). The bottom sediments from the dredge hauls were washed through a U.S. Standard #30 mesh soil sieve and the residues were placed in pint jars. Qualitative plankton samples were collected at several locations (Figure 2) with a standard plankton net (#25 silk bolting cloth). All samples were preserved with formalin and returned to the Water Resources Commission laboratory in Lansing for analysis. The extent of discoloration was determined by taking water transparency readings with a standard Secchi disk.

Results and Discussion

One benthic animal was found in the eight bottom samples collected during this survey (Table 1). This scarcity of benthic animals reflects the poor environment afforded by a shifting sand bottom. Sandy shoreline areas subjected to wave action provide an unstable habitat for macroinvertebrate animals. The entire shoreline sediments were stamp sand in the Freda-Redridge area. Therefore, it is difficult to evaluate the effects of suspended tailing materials from the Freda Copper Mill on the basis of benthic macroinvertebrates in this area.

Plankton samples were also of little help, if any, in evaluating the areas that were adversely affected. Table 2 shows no discernible differences in the various plankton communities sampled.

The shore waters in the Freda-Redridge area were rusty red-brown in color. The extent of the discoloration is shown in Figure 3. The discoloration was the result of the Freda mill tailings discharge which consists of 100 tons/day of very finely ground rock, commonly called stamp sand (99% will pass through a #30 U.S standard soil sieve). Secchi disk readings off the point of discharge were: 6" at 10 yards; 2' at 30 yards; and 25' at 300 yards. The surface waters were clear but the turbid wastewater was very apparent underneath. The turbid waters followed the shoreline for a short distance, then broadened out. The finely ground materials were suspended in the surface waters along a discrete inshore water mass. This area was red-brown in color. Beyond this red-brown streak was a distinct fringe area of gray color. The gray color was a result of the sediments being at a greater depth. Beyond the gray fringe area was the normal clear blue color of Lake Superior. The demarkation between the red-brown, gray and blue waters was very sharp and distinct. Lake Superior was visually discolored for 3/4 miles offshore in the vicinity of Redridge and for 5 or more miles along shore to the NE towards the Portage Lake shipping canal. Mr. Joseph Bal has observed this discoloration previously and stated that on occasion that it has extended to the Portage Lake shipping canal which is 12 miles NE of Freda.

Summary

1. Benthic macroinvertebrate samples were collected in the Freda-Redridge vicinity. Analyses of these samples failed to reveal useful information concerning the effects of the Freda Copper Mill tailing wastes on the aquatic environment.

2. Plankton samples collected during this survey showed that there were no discernible differences in the various plankton communities sampled.

3. Visual observations and Secchi disk readings showed that finely ground rock materials discharged from the Freda Copper Mill were discoloring the inshore water mass in the Freda-Redridge area.

Report by:

D. James Seeburger, Aquatic Biologist
Water Quality Appraisal Unit
WATER RESOURCES COMMISSION
Michigan Department of Natural Resources

dd
March 1969

Figure 1. Bottom fauna sampling locations in Lake Superior, vicinity of the Freda Copper Mill, Freda, Michigan, August 24 and 27, 1966.

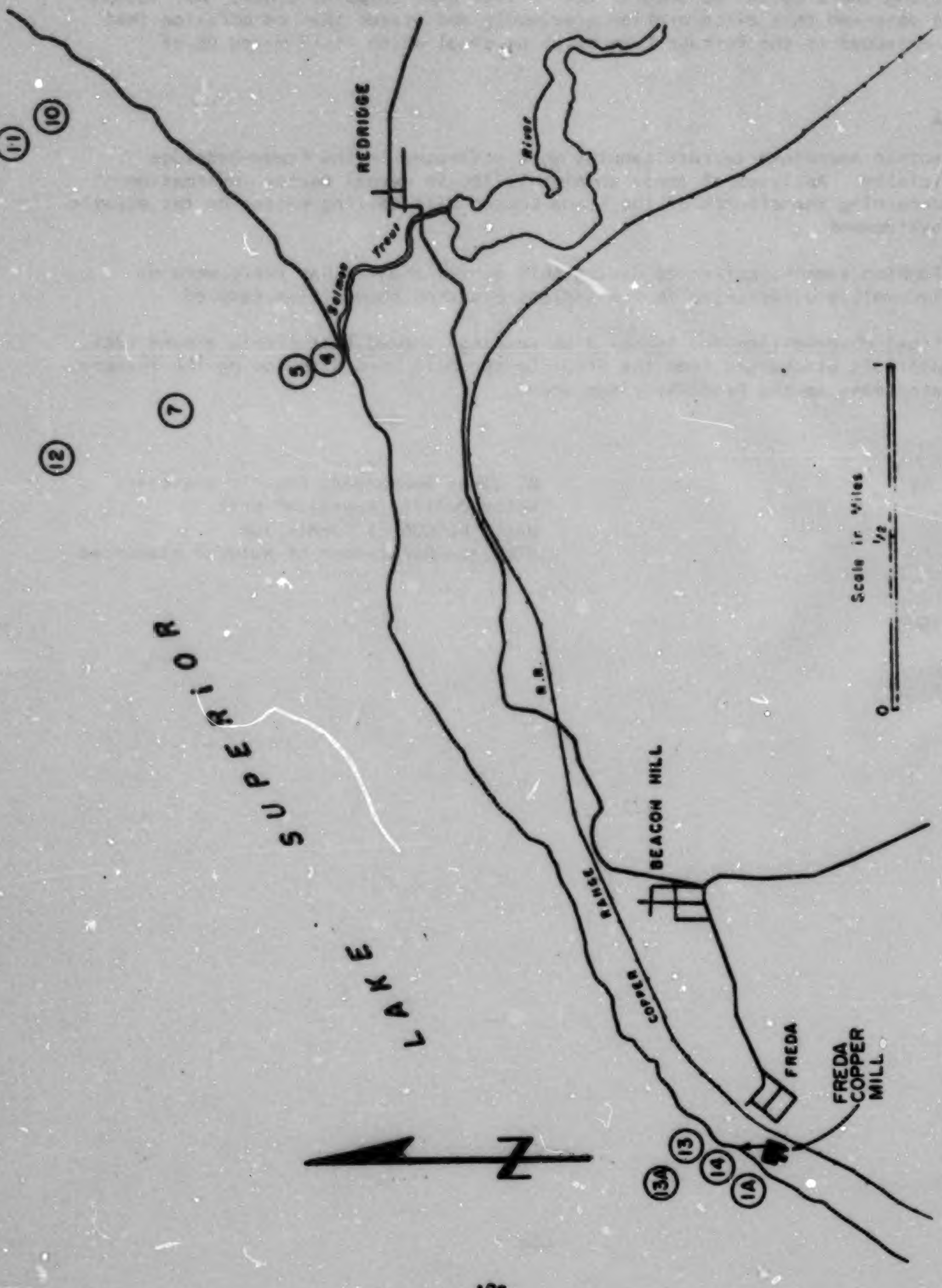

REDRIDGE
River
Salmon Trout
11
10
5
4
7
12
LAKE SUPERIOR
R.R.
BEACON HILL
COPPER RANGE
FREDA
FREDA COPPER MILL
N
13
14
13A
1A
Scale in Miles
0
1/2

Figure 2. Plankton sampling locations in Lake Superior, vicinity of the Freda Copper Mill, Freda, Michigan; August 24 and 27, 1966.

3-11-69

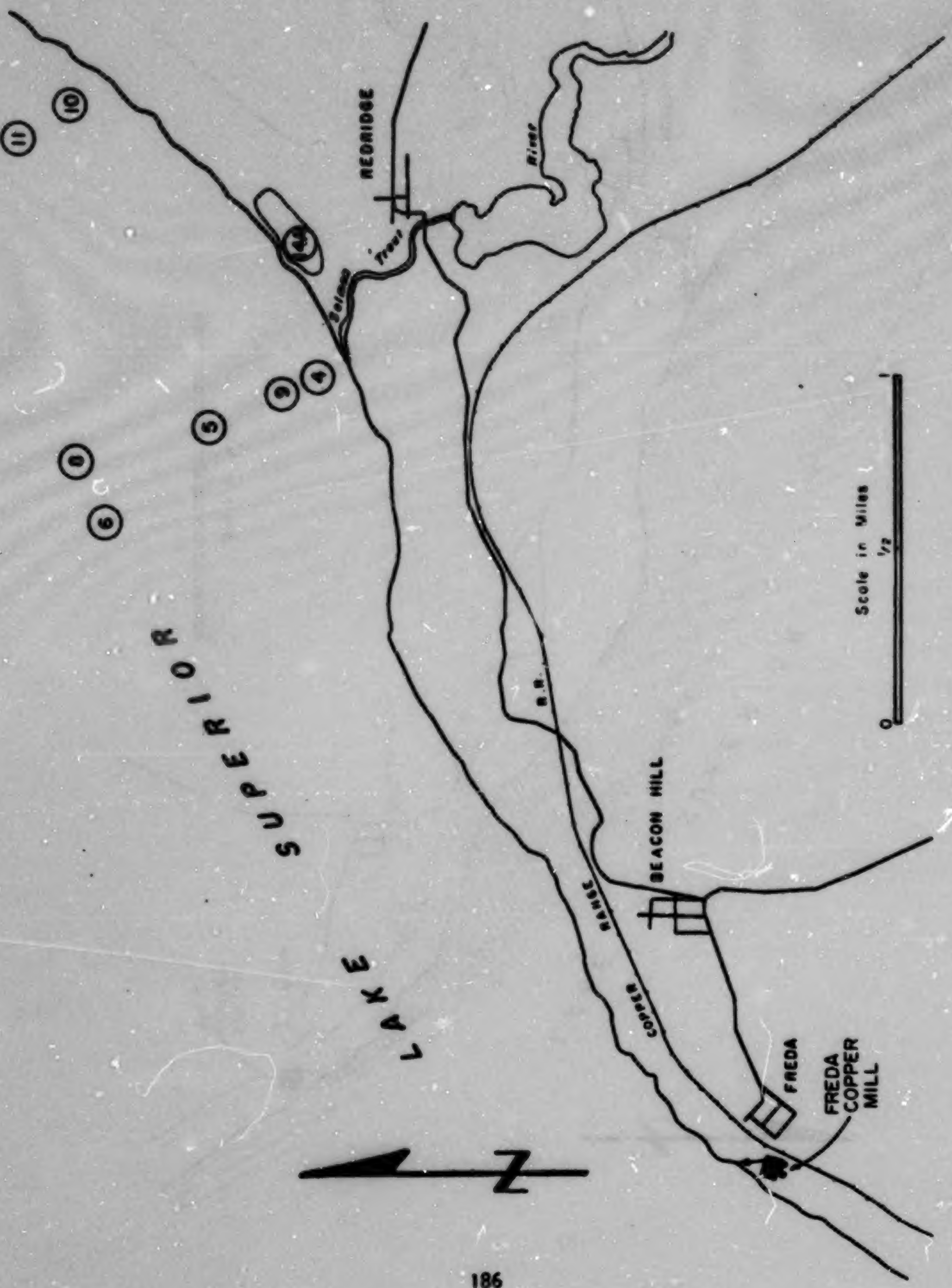

11
10
14
4
3
5
8
6
LAKE SUPERIOR
REDRIDGE
Salmon
Trout
River
R.R.
BEACON HILL
RANGE
COPPER
FREDA
FREDA COPPER MILL
Scale in Miles
0
1/2
1
N

Figure 3. Extent of Lake Superior waters discolored by the Freda Copper Mill discharge, Freda, Michigan, August 24 and 27, 1966.

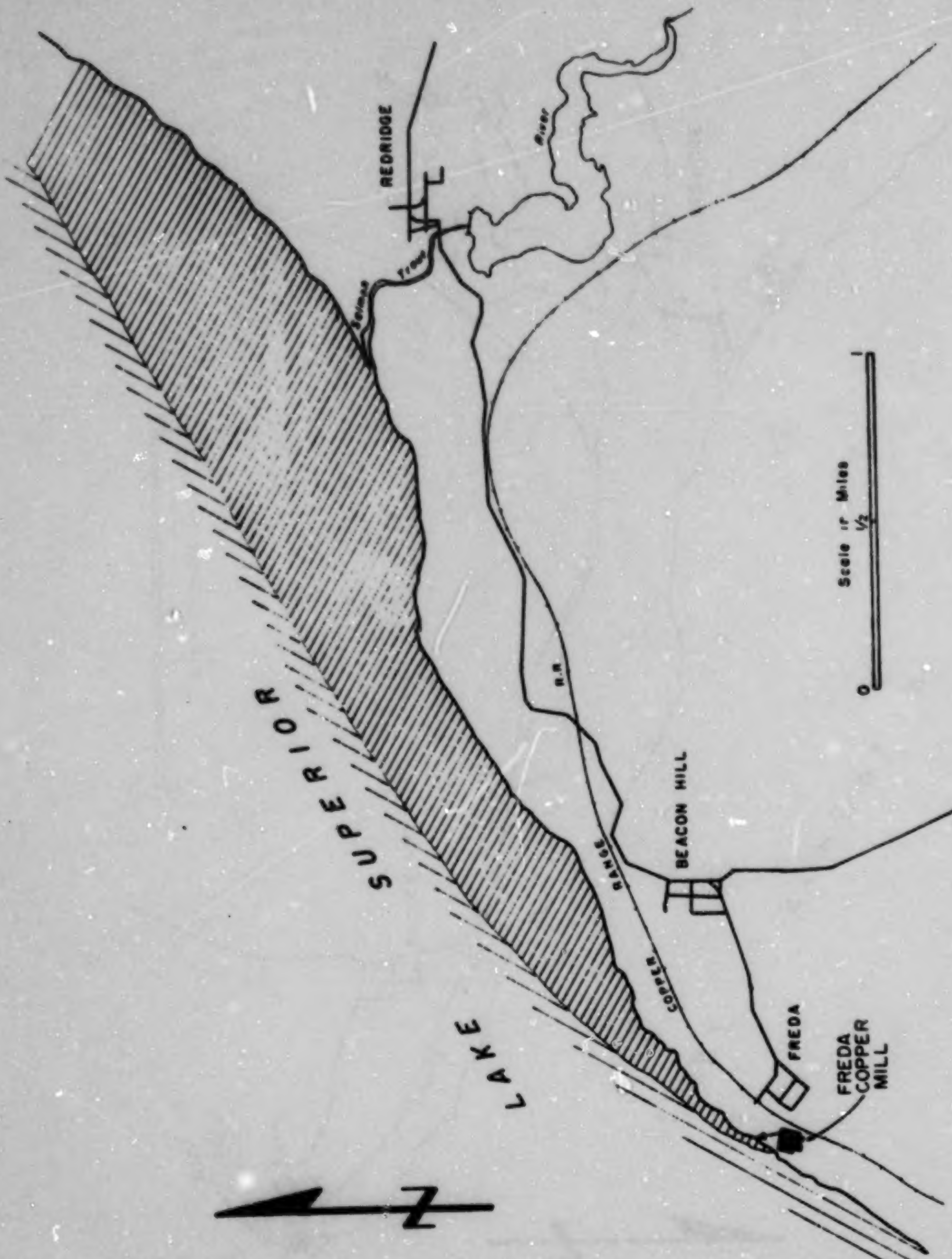

REDRIDGE
Salmon Trout River
R.R.
COPPER RANGE
BEACON HILL
FREDA
FREDA COPPER MILL
LAKE SUPERIOR
N
Scale in Miles
0
½
1

Table 1. Benthic macroinvertebrate survey, Lake Superior in the vicinity of Freda and Redridge, Houghton County, Michigan, August 26 and 27, 1966.

Station Number	1A	4	5	7	10	11	12	13	13A	[illegible]
Location*	100 yds off Freda mill	150 yds off Redridge	½ mile off Redridge	3/4 mile off Redridge	1 1/8 mile NE of Redridge 150 yds off-shore	1 1/8 mile NE of Redridge 500 yds off-shore	3/4 mile off shore at Redridge	100 yds NE of Freda mill 50 yds off-shore	100 yds NE of Freda – 50 yds off-shore	50 yds out from Freda mill
Type of Sample	areal	areal	areal	areal	areal	areal	qualitative	areal	qualitative	areal
Sampler used	Ponar	Ponar	Ponar	Ponar	Ponar	Ponar	Grab	Ponar	Grab sample	Ponar
Depth	6'	17'	17'	48'	14'	20	surface	4'	surface	8
Macroinvertebrates found	none	none	none	1-midge *Micropsectra* sp.	none	none	midge pupae cast skins–some adults were on the water surface	none	several Simulium larvae	none
Bottom type	fine sand	fine sand with moderate amount of stamp sand.	fine sand	fine to coarse gravel	fine sand with small amount of stamp sand	rocky	unknown	fine sand and moderate amount of stamp sand	unknown	rock - stamp sand

* See map for Location(Figure 2).

Table 2. Plankton sample results, Lake Superior, in the vicinity of Freda and Redridge, Houghton County, Michigan, August 24 and 27, 1966.

Station Number	4	5	6	8	9	10	11	14A
Location*	150 yds off Redridge	½ mile off-shore at Redridge	3/4 mile off-shore at Redridge	3/4 mile off-shore at Redridge	100 yds off Salmon trout River	1 1/8 mile NE of Redridge, 150 yds off-shore	1 1/8 mile NE of Redridge 500 yds off-shore	Beach pool Redridge beach
Type of sample	10' plankton tow	10' plankton tow	10' plankton tow	10' plankton tow	3 minute plankton tow	10' plankton tow	10' plankton tow	Grab
Depth	vertical	vertical	vertical	vertical	surface	vertical	vertical	surface
Organisms found	Dinobryon Asterionella Anabaena Tabellaria Fragilaria Polyarthra Ceratium Nauplius	Synedra Fragilaria Asterionella Polyarthra Dinobryon Tabellaria Trichocerca Keratella Kellicottia	Fragilaria Tabellaria Polyarthra Keratella Dinobryon Ceratium Daphnia Kellicottia Anabaena Pediastrum Oscillatoria Copepoda Synedra Nauplius	Polyarthra Fragilaria Asterionella Dinobryon Daphnia Tabellaria Kellicottia Ceratium Pediastrum Anabaena Copepoda Navicula Hydrachnellae	Fragilaria Tabellaria Pediastrum Dinobryon Synedra Ceratium Staurastrum Keratella Daphnia Polyarthra Copepoda Kellicottia Anabaena	Fragilaria Polyarthra Synedra Asterionella Dinobryon Anabaena Kekatella Cymbella Ceratium Daphnia	Copepoda Daphnia Cymbella	Protococcus

* See map for location(Figure 2).

APPENDIX T

BIOLOGICAL SURVEY OF SOUTH BAY, LAKE SUPERIOR AND OBSERVATIONS ON THE ANNA RIVER MUNISING, ALGER COUNTY MICHIGAN

MICHIGAN WATER RESOURCES COMMISSION

A Biological Survey of
SOUTH BAY, LAKE SUPERIOR
and Observations on
THE ANNA RIVER
Munising, Alger County, Michigan

August 6, 1968

On August 6, 1968 a biological survey was conducted on South Bay, Lake Superior and its major tributary, the Anna River. In 1957 a Water Resources biological survey established that the benthic area of South Bay in close proximity to Munising was biologically depressed. The present study is designed to determine water quality conditions and detect any changes in the benthic macrofaunal community that may have occurred since the 1957 survey.

In 1957 the principal water quality problem appeared to arise from the Kimberly-Clark Corporation Munising Mill (paper) discharges. This company has since made a tremendous effort to correct these problems in their wastewater discharge to South Bay. A 1951 Water Resources Commission industrial survey determined sulfite waste liquor releases amounting to 95,000 pounds of biochemical oxygen demand (BOD) per day. In 1959 a Water Resources Commission industrial survey found this loading reduced to 31,000 pounds of BOD per day. A large part of this reduction was due to the use of waste sulfite liquor as a road binding material by Schoolcraft and Alger counties.

In 1951, approximately 1,200 cubic feet of bark was discharged to South Bay during every 24 hours of wood room operation. This was measured by a $\frac{1}{4}$ inch mesh screen bucket. In 1959 no losses could be measured by this method.

In 1951 fiber losses amounted to 4.73 to 5.5 percent of production. This was reduced to 3.49 percent in 1959.

In February, 1962 Kimberly-Clark closed its local pulp mill. This halted all bark and sulfite liquor losses to South Bay. Continued production is based upon pulp supplied by other Kimberly-Clark mills. In 1962, two Sveen-Peterson save-alls were installed on the paper machines to further reduce fiber losses. Also in 1962, the discharge of sanitary sewage to the bay was halted.

Thus, at present, only boiler blow-down and mill white water is being discharged. These wastes are treated with alum and ponded before release. Inorganic dyes are discharged to the bay periodically. A filled portion of shoreline behind the plant is used for a dump and considerable burning occurs there. The mill and the City of Munising are jointly planning to provide a sanitary landfill for solid waste disposal.

Prior to 1960, sewage from the City of Munising was discharged to South Bay either directly or through the Anna River. The Munising primary wastewater treatment plant was placed in operation in October, 1960 and discharges to the Anna River approximately one mile above South Bay. The sewer system is combined storm and sanitary sewers so that stormwater runoff passes through the plant. Several ground springs are connected to the sewer system. This plant services approximately 4,220 people.

A municipal septic tank services an area along the west shore of South Bay. This system is directly connected to the bay and is chlorinated. Storm sewers were connected to the septic tank until 1967.

The Kimberly-Clark discharge channel lies approximately 1,000 feet due west of the Anna River mouth. Both are on the extreme south end of the bay.

METHODS

Quantitative (areal) collections and qualitative samples of the benthic animal life of South Bay and vicinity were taken with Ekman and Ponar dredges at 22 stations (Figure 1). Qualitative collections were made at two locations in the Anna River, above and below the Munising WWTP (Figure 1). These samples were sieved with a U.S. Standard #30 brass bucket sieve, labeled and preserved. Samples were washed, sorted, identified, and tabulated in the Lansing laboratory.

Animals were assigned a tolerance status according to published accounts and the past experience of Water Resources staff biologists. Tolerance status refers to the animal's relative ability to withstand and/or respond to adverse environmental conditions. Individual tolerances are generally derived from an animal's reaction to organic wastes and attendent oxygen depletion or modification of bottom deposits.

Tolerance status may be generally defined as:

Tolerant - organisms that can grow and develop within a wide range of environmental conditions. They are often found in water of poor quality. These species are generally insensitive to a variety of environmental stresses.

Intolerant - organisms whose growth and development are dependent upon a narrow range of optimum environmental conditions. They are rarely found in areas of organic enrichment. They cannot adapt to adverse situations and are replaced by less sensitive organisms if the quality of their environment is degraded.

Facultative - organisms with the ability to survive over a wide range of conditions. They possess "medium" tolerance and often respond positively to moderate organic enrichment but cannot tolerate severe environmental stresses.

In addition to tolerance status, the diversity of animals present in a given benthic community is significant. In general, pollutional communities are characterized by a very low species diversity, while normal undisturbed communities contain many different species.

Water samples were collected from the Anna River and South Bay and analyzed by the operator of the Munising Wastewater Treatment Plant.

ANNA RIVER

The Anna River arises in Section 7 of T46N, R19W with Anna Lake as its headwater. The Anna River is 15 miles long, flowing east and north, entering Lake Superior at Munising. The flow is through hilly wooded terrain. The Anna is a clear coldwater stream with a number of small spring fed tributaries. The highest summer temperature on record is 57 °F.

The Anna River has long been a good brook trout stream, and also contains rainbow and brown trout. Coho salmon were planted in the spring of 1968.

Fish Survey

On October 16, 1967 Fish Division personnel conducted a fish survey of the lower Anna River. The three downstream stations provide information on fish populations both above and below the Munising WWTP outfall.

Station 1. Upstream for 200 feet from the M-28 bridge. The water was clear. Cover was considered poor for larger trout.

4	Brown trout	1.4 - 2.2 inches
21	Rainbow trout	1.8 - 5.0 inches
22	Mottled sculpins	2.0 - 4.2 inches
3	Central mudminnows	2.5 - 3.8 inches

Large numbers of rainbow fingerlings were seen but not collected.

Station 2. From a point 400 feet north of the M-28 bridge, upstream for 200 feet. Habitat was excellent for trout. The water was clear. Efficiency was poor due to swift current and deep pools.

5	Brown trout	4.8 - 17.0 inches
8	Rainbow trout	1.6 - 8.0 inches
1	Mottled sculpins	2.5 inches

Numerous fingerling trout and sculpins escaped through the large net.

Station 3. From a point 50 feet above the M-94 bridge, downstream 180 feet. The water smelled of sewage and was turbid. Habitat was excellent for trout. Efficiency poor due to swift turbid water. Pollution suspected.

1	Brook trout	6.1 inches
2	Rainbow trout	6.2 - 8.2 inches
3	Mottled sculpins	3.0 inches
1	Burbot	6.6 inches

The Munising WWTP outfall is located between stations 2 and 3 and is the source of turbidity, sewage odors, and the notation "pollution suspected" found on the fish survey forms. Station 3, downstream from the WWTP outfall, contained much lower numbers of trout than did stations 1 and 2 above the outfall.

Biological Survey

On August 6, 1968 qualitative collections of benthic animal life were taken above and below the Munising WWTP outfall. The species found at these stations are tabulated in Table 1. The community structures are depicted according to tolerance to pollution in Figure 2.

Station AR-1. Upstream from the M-28 bridge. The clear water was flowing over a sandy bottom. No rocky substrate was exposed. The bank was undercut, containing some submerged branches. The aquatic moss Drepanocladus was scattered. No algal growths were observed.

The branches along the bank were heavily populated with mayflies (Baetis) and blackflies (Simulium). The intolerant scud Gammarus was very abundant. Intolerant stoneflies (Nemoura), mayflies (Ameletus), and caddisflies (Trentonius, Brachycentrus, Pycnopsyche) were represented. Certain midges were abundant (Cricotopus, Prodiamesa, Metriocnemus) and aquatic worms (Naididae, Stylodrilus) were occasional. Other animals included beetles, midges, dipterans, clams, and fish.

The fauna of this river reach was diverse and balanced, characteristic of cleanwater conditions. Of the 24 species found in qualitative collections, six were intolerant, 15 facultative, and three tolerant.

Station AR-2. Approximately 500 feet downstream from the WWTP outfall. The water was swiftly flowing, turbid, and contained considerable sewage solids. Toilet paper was common streaming on snags and floating in the water. Both water and sediments emitted strong sewage odors. The sandy substrate was much like that of station AR-1 except for a black sludge deposited along both margins.

Tolerant sowbugs (Asellus) were dominant in this river reach. Certain midges (Hydrobaenus, Prodiamesa) were very abundant. The intolerant scud (Gammarus) and caddisfly (Pycnopsyche) were found in very low numbers. The condition of the habitat strongly suggests that these intolerant forms were the result of drift from upstream by the extremely swift current. Animals found in low numbers included other midges, clams, snails, and beetles.

The benthic community in this river reach is much more restricted than that found upstream. Of the 18 species represented in collections, two were intolerant, 11 facultative, and five tolerant.

Discussion of Anna River Data

Fish survey stations 1 and 3 correspond generally with biological survey stations AR-1 and AR-2. Both surveys found cleanwater populations upstream and limited populations downstream. Stream habitat was degraded by the accumulation of black organic sludge and increased turbidity of sewage origin.

The normal action of an organic waste load in a river or stream is the exertion of considerable stress upon dissolved oxygen concentrations. This is not so in the Anna River. Because of the extremely low temperature (57 °F) and swift flow, there is little effect upon dissolved oxygen before these wastes reach South Bay. As a result the biological populations found downstream were of an extremely limited nature, with many species barely represented by only one or a very few individuals. In warmer receiving waters this discharge would most probably result in a virtual destruction of the downstream fish and benthic animal populations.

SOUTH BAY

South Bay is the southern extension of Grand Island Harbor, located centrally along the Michigan Lake Superior shoreline. It is a natural bay, approximately 2.5 miles long and 1.5 miles wide, surrounded by high rocky hills. Grand Island lies directly offshore to the north providing excellent protection from the strong Lake Superior winds. The water is deep, 50-80 feet in the inner bay gradually increasing to over 200 feet in the outer bay. Numerous small tributary streams enter along the eastern shoreline and the Anna River enters in the southern extremity. The City of Munising borders the southeastern, southern, and southwestern shorelines. The outer bay maintains a good population of lake trout, whitefish, and smelt. Yellow perch, herring, burbot, suckers, and bloaters are also represented. The 22 benthic sampling stations in South Bay are located in Figure 1. To facilitate interpretation of the macroinvertebrate findings of this survey stations have been separated into two zones, the littoral and profundal. This separation is necessary since shallow water samples cannot be compared directly to deep water samples in a valid manner.

Littoral Zone - Stations 1,2,3,4,4a,5,6,13,14,18,19,21,22,23

Fourteen bottom samples were taken at distances between 400 and 17,600 feet from the river mouth at depths between 25 and 37 feet. Description of bottom materials and sampling depths are presented in Table 2. In general the bottom deposits of the littoral zone contained large quantities of bark, wood chips, and woody frass. Wood chips made up the entire substrate sample at station 3. Paper mache was the only substrate found at station 4. The outer bay samples (stations 19,21,22) contained considerable bark and wood buried deep in the red clay.

Identifications and tabulations of the benthic fauna samples are presented in Table 3, graphically illustrated in Figures 3 and 4, and summarized in Table 4. With the exception of stations 3,4,4a, and 5, the littoral zone of South Bay supported a diversified fauna, including many animals associated with clean water environments. Intolerant animals included mayflies (Hexagenia limbata), caddisflies (Psychomyiidae, Oecetis, Mystacides), scuds (Pontoporeia, Gammarus), and midges (Hydrobaenus nivorundus, Diamesa campestris). Species representation in the samples ranged from 9 to 27 species. The outer bay stations 18,19,21, and 22 contained exceptionally diverse benthic communities. Station 2 appeared to be of marginal character.

Stations 3,4,4a, and 5 are at the extreme south end of South Bay in the vicinity of the Kimberly-Clark discharge and the mouth of the Anna River. These stations were found to contain very limited benthic communities of pollution tolerant midges (Procladius, Prodiamesa) and sludgeworms (Limnodrilus). No animal life was detected in the paper mache substrate of station 4.

Profundal Zone - Stations 7,8,9,10,11,15,16,17

Eight Bottom samples were taken at distances of 2,000 to 7,400 feet from the Anna River mouth at depths between 53 and 90 feet (Table 2). Bottom materials were generally a reddish-brown silt with considerable quantities of associated bark, wood chips, and woody frass.

Identifications and tabulations of the benthic fauna samples are presented in Table 5, graphically illustrated in Figure 5, and summarized in Table 6. These data indicate conditions of degradation in the benthic communities at stations 7,10, and 11. Pollution tolerant midges (Procladius) and sludgeworms (Limnodrilus) dominate the limited community structure. Tolerant animals comprised 78 to 100 percent of the individuals collected at these locations.

The remaining profundal stations (8,9,15,16,17) contained reasonably diversified faunas when considering the limiting factor of increased depth. The intolerant scud Pontoporeia affinis was the dominant animal, comprising 35 to 72 percent of the individuals. Tolerant animals comprised only 9 to 27 percent of the samples.

Littoral Zone - 1957 and 1968

Seven locations along the littoral zone were sampled both in 1957 and 1968 (1968 stations 1,2,3,6,19,22,23). A comparison of summary data from these two collection dates is provided in Table 7 and the number of species by tolerance status is depicted in Figure 6. These data show very little change occurring in the benthic community structure of South Bay in the eleven years between measurements. The similarities between sampling dates are remarkably close. Only at station 2 is there a difference and it is quite sharp. The number of species dropped from 19 in 1957 to 9 in 1968. Most of the loss was in the facultative portion of the community. As was mentioned earlier, station 2 is of marginal condition. This decline from 1957 may be due to increased usage of the municipal dock for boating activities.

Plankton Samples

Plankton samples of surface waters were taken at two locations in South Bay. Analysis of these samples (Table 8) show the phytoplankton to consist of very low numbers of diatoms (Tabellaria, Navicula, Cymbella, Fragilaria, and Asterionella), both in the inshore and mid bay waters. Secchi disk readings were in excess of 20 feet throughout the whole bay.

Water Chemistry

Water grab samples for chemical analysis were collected from southern inshore waters of South Bay in the vicinity of the Kimberly-Clark discharge and the Anna River mouth (Table 9). At the time these samples were taken, Kimberly-Clark was releasing red dye to the bay. Observations on the discolored waters of South Bay determined that Kimberly-Clark's wastewaters move northeast and east into the bay. The wastewater was 20 °F warmer than the bay waters (66 °F) and stayed at the surface. The cold (57 °F) Anna River water sunk underneath the warmer bay waters and apparently moved straight out into the bay. Kimberly-Clark's discharge contained a BOD of >20 mg/l and suspended solids of 21 mg/l. The Anna River water contributed a BOD of 7 mg/l and suspended solids at 14.8 mg/l.

Dissolved oxygen profiles were taken at two locations, 900 feet north of the Kimberly-Clark discharge and at mid bay south of benthic sample station 15(Table 10). The dissolved oxygen levels were at least 100% of the saturation value at the surface and bottom for both profiles. More than sufficient dissolved oxygen was found at all depths in both profiles.

Discussion of South Bay Data

The quantitative collections were used to closely evaluate the benthic macroinvertebrate community of South Bay. Differences were found with respect to the number of species capable of inhabiting the benthos; the type or quality of organisms found; and conditions of balance within the benthic community structure as shown by the number of species - number of animals relationship (Tables 4 and 6).

Generally, a natural, unpolluted aquatic environment will support many different kinds of organisms but relatively few individuals of a given species because of predation and competition for food and living space. The converse most often exists in waters polluted with organic wastes. In such an environment, most predators are eliminated by water quality or substrate changes. Living space presents no problem because remaining organisms must be well adapted to live in organic sludge and food is seemingly inexhaustable. Thus, as the environment is degraded, the number of species that can tolerate this degradation becomes smaller.

The type, or tolerance status, of species inhabiting a given environment provides information as to the pollutional status of that environment. A biotic index was used to evaluate those species found according to their ability to withstand degraded environmental conditions. The formula B.I. = 2(I) + F was used, where I = the number of intolerant species and F = the number of facultative species. This weights the intolerants, includes the facultatives, and disregards the tolerant forms. Lower values indicate reduced representation of the more sensitive intolerant-facultative portion of the benthic community.

Margalef (1951) determined that a diversity (d) measured by $d = s-1/l_nN$ (where s = number of species, l_nN = natural logarithm of number of individuals) could be used to relate number of species to number of animals. Thus, when this method is applied to aquatic communities, the higher values indicate greater diversity or increased balance of the benthic community. These higher diversity values indicate clean water conditions where many different kinds of organisms are found, but few individuals. As conditions are degraded, fewer species and increased numbers of individuals are found, resulting in an unbalanced benthic community. This imbalance is reflected by low diversity values.

Differences between various portions of South Bay with respect to total numbers of species, biotic index, and diversity index is presented in Table 11. These data show a cone-shaped zone of degradation encompassing approximately one mile of shoreline and extending roughly 4,000 feet into South Bay (Figure 7). In addition the littoral community of the inner bay (Stations 1,2,6,13,and 14, outside the zone of degradation) is less characteristic of clean water conditions than that of the outer bay (Stations 18,19,21,22,and 23) and may be considered as a zone of influence and the zone of clean water, respectively. Profundal stations 8,9,15,16, and 17 are not classified.

It is impossible, with the data available, to define or separate the effects of the individual discharges from the Munising WWTP and Kimberly-Clark upon the benthic ecology of South Bay. It is obvious that past deposits of fiber and wood are still exerting a considerable influence upon the benthic community of the entire inner bay. Deposits of cellulose materials such as fibers, bark, and wood chips are extremely resistant to biodegradation and retain their influence upon the benthos for exceptionally long time spans.

The discharges from the Kimberly-Clark Corporation Munising Mill wood room and production operations contributed large quantities of woody materials prior to 1959. Other sources of these woody deposits include: a veneer mill that once operated at the south end of the bay; a large Ford sawmill that once operated along the west shore; the past practice of rafting logs in South Bay in which considerable debarking occurred; and a small sawmill presently in operation just south of the old Ford sawmill.

These deposits tend to mask any adverse effects that may result from the present discharges by the WWTP and paper mill. Of the adverse conditions found within the zone of degradation, however, none could be attributed as a direct result of the present discharges, although there is undoubtly a degree of influence exerted in the close shoreline vicinities.

A comparison of seven stations sampled both in 1957 and 1968 shows virtually no change in benthic community structure in the 11 years between measurements. During this period marked improvements were made in paper mill waste control and municipal sewage treatment.

Water chemistry of the extreme southern inshore waters shows a small increase in suspended solids and biochemical oxygen demand, but is of a very limited nature. Dissolved oxygen in the mid bay and offshore waters was more than adequate (at least 100 percent of the saturation value) at all depths. Planktonic algae populations were comprised of very low numbers of diatoms. Secchi disk readings were in excess of 20 feet throughout the bay. These data show no indications of any adverse water quality existing in the water column of South Bay.

The benthic community measured in close proximity to the community septic tank at the west side of South Bay was well balanced and provides no evidence of adverse effects arising from that facility.

The benthic community just off the municipal dock was of marginal character. A sharp decline from the species numbers present in 1957 was detected in 1968. This may be due to increased pleasure boating activities in the vicinity and the resulting losses to the bay of oils, sewage, and other materials.

Contribution of materials from the Anna River watershed above Munising should be very limited and of no consequence to water quality.

SUMMARY

1. A biological survey was conducted on South Bay, Lake Superior, in the vicinity of Munising, Michigan on August 6, 1968. Observations on the Anna River, South Bay's major tributary, were made at the same time.

2. Studies on fish and benthic animal communities in the Anna River show clean water populations upstream and limited populations downstream from the Munising Wastewater Treatment Plant. The downstream populations are in a very delicate balance with many species barely represented in the fauna. The extremely cold water of the Anna River prevents the organic loading from exerting its full effect upon the biological populations.

3. Most bottom sediments of South Bay contained large quantities of bark, wood chips, and woody frass. These materials generally decreased in quantity with increased distance from the southern end of South Bay. Two stations just offshore from Kimberly-Clark contained completely artifical substrates, one entirely of wood chips, the other entirely of paper mache.

4. A cone-shaped area of degradation was identified in the southern portion of South Bay. This area encompassed approximately one mile of shoreline and extended nearly 4,000 feet into the bay. The benthic community within this area was severely limited, comprised mainly of pollution tolerant sludgeworms and midges.

5. The remaining portion of South Bay supported a diversified benthic community structure. However the littoral communities found in the extreme outer bay were much more diverse than those found in the littoral area of the inner bay.

6. A comparison of benthic stations sampled in 1957 and 1968 showed remarkably close community structures, indicating almost no changes during the 11 years between measurements.

7. Plankton samples, dissolved oxygen profiles, and inshore measurements of biochemical oxygen demand and suspended solids show no adverse water quality conditions in the water column of South Bay.

8. It appears that the principal source of degradation of South Bay, Lake Superior, arises from previously deposited woody materials which are still exerting a considerable influence upon the benthic ecology. This is substantiated by data showing almost no change in the benthic community between 1957 and 1968, even though marked improvements were made in paper mill waste control and municipal sewage treatment during that period.

Field and laboratory work supervised by:	Ronald B. Willson, Aquatic Biologist
Report by:	Ronald B. Willson Water Quality Appraisal Unit WATER RESOURCES COMMISSION Michigan Department of Natural Resources

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1. Margalef, R. 1951. Diversidad de especies en las comunidades naturales. Proc. Inst. Biol., Apl. 9, 5. In Wilhm, Jerry, 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes Jour. FPCF Vol. 39, No.10, Part 1:1673-1683.

2. Michigan Department of Natural Resources, Fish Division, Technical Records.

3. Michigan Department of Natural Resources, Water Resources Commission, Records.

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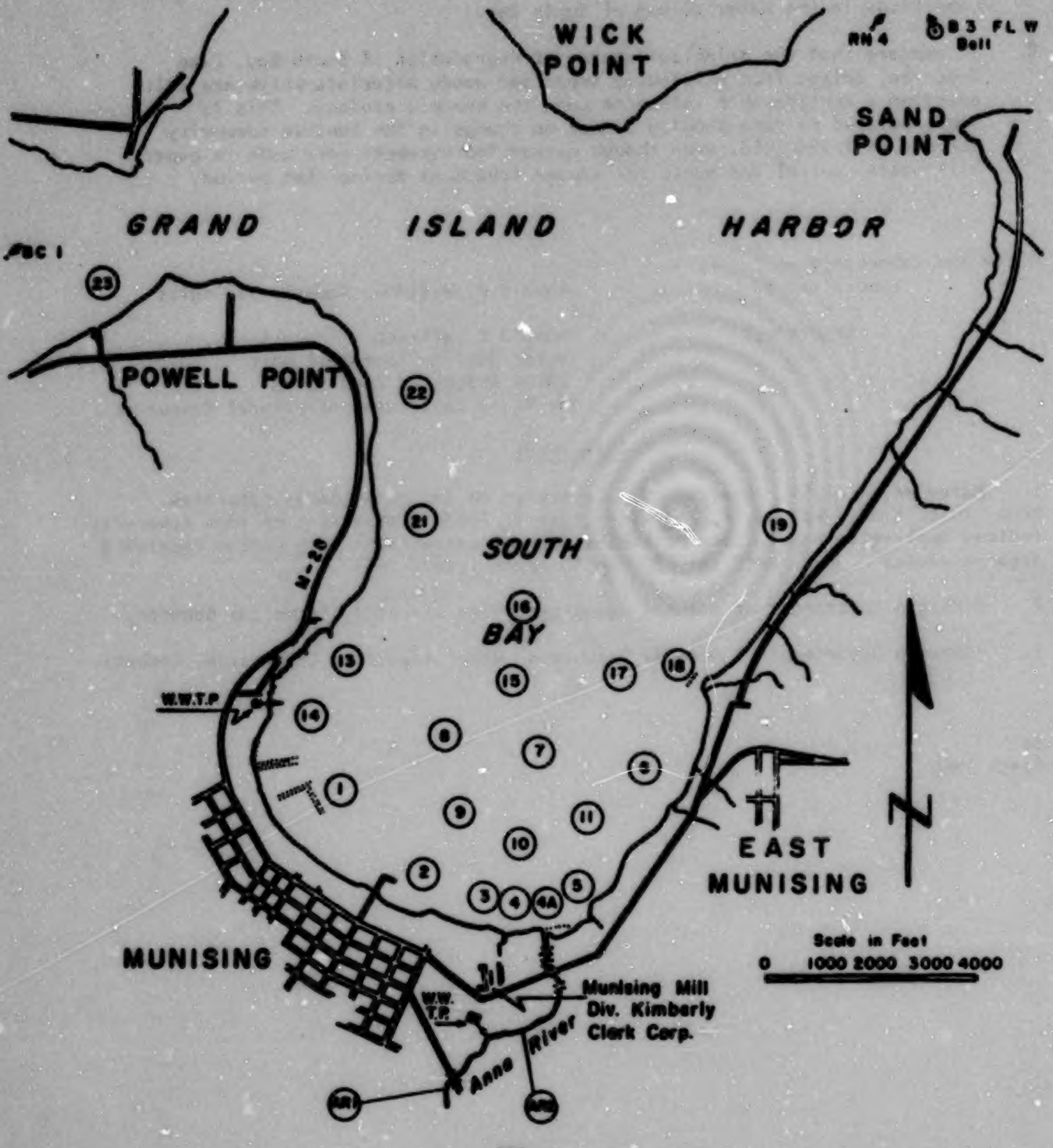
March 1969

Figure I. South Bay, Lake Superior Biological Sampling Locations
August 6, 1968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B 3 FL W
Bell
SAND POINT
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PBC I
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POWELL POINT
22
21
M-28
SOUTH
BAY
19
16
13
15
17
18
W.W.T.P.
14
6
7
8
1
9
11
10
2
3
4
4A
5
EAST MUNISING
MUNISING
W.W. T.P.
Munising Mill
Div. Kimberly
Clark Corp.
Anna River
AR1
AR2
Scale in Feet
0 1000 2000 3000 4000

Table 1. Benthic animals found in qualitative collections during a biological investigation of the Anna River, Munising, Alger County, Michigan, August 6, 1968. Relative abundance of organisms is indicated by VA(very abundant, >25), A(abundant, 11-24) C(common, 6-10), O(occasional, 2-5), and P(present, 1).

		Station:	AR-1	AR-1
Tolerance Status	Scientific name	Station: Location:	M-28 bridge above Munising WWTP	500' above Munising WWTP
F	*Stylodrilus heringianus*		O	O
T	*Asellus militaris*			VA
F	*Hydrobaenus* sp.			VA
T	*Prodiamesa* sp.		A	VA
T	*Prodiamesa olivacea*		P	A
F	*Metriocnemus lundbecki*		A	C
T	*Physa* sp.			O
T	*Pisidium* sp		P	O
I	*Gammarus fasciatus*		A	O
F	*Smittia ephemerae*		P	O
F	*Calopsectra*		O	O
I	*Pycnopsyche* sp.		A	P
F	*Hydaticus* sp.			P
F	*Anatopynia* sp.		P	P
F	*Odontomesa fulva*			P
F	*Tanytarsus* sp.			P
F	*Glyptotendipes lobiferus*			P
F	Naididae		P	P
F	*Anacaena limbata*		P	
F	*Chrysops* sp.		P	
I	*Nemoura* sp.		O	
I	*Ameletus ludens*?		O	
F	*Baetis* sp.		VA	
F	*Stenelmis* sp.		P	
F	*Simulium* sp.		C	
I	*Trentonius distinctus*		C	
F	*Hydropsychidae*		O	
I	Brachycentrus *americanus*		O	
F	*Cottus bairdii*		O	
F	*Cricotopus trifasciatus*		C	
F	Oligochaeta(aquatic earthworms)		O	
	Total number of species		24	18
	Number of intolerant species(I)		6	2
	Number of facultative species(F)		15	11
	Number of tolerant species(T)		3	5

Figure 2. Number of animal species found in qualitative samples depicted according to their tolerance status, Anna River, Munising, Alger County, Michigan, August 6, 1968.

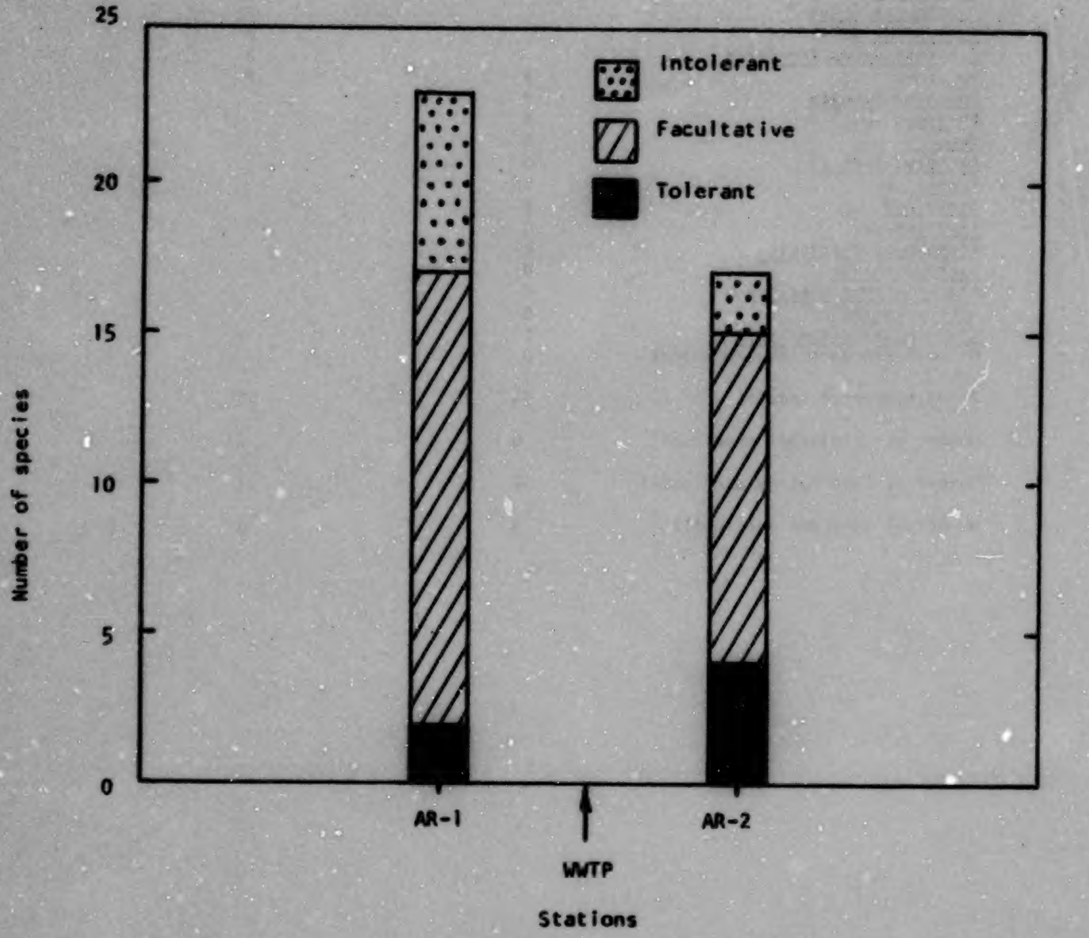

Table 7. Summary of field observations on South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

Station Number	Station location	Distance from Anna River (ft.)	Depth (feet)	Bottom composition
1	250-300 feet off L-type pilings along west shore	6,200	30	Sand and red silt. Fine wood chips, bark, woody [illegible] Some Chara.
2	200 feet off end of municipal dock	2,200	32	Black silt, very little sand. Large quantity bark, woody frass, and plant debris. Oils observed.
3	300' from shore, due north of water tower	1,700	37	Some brown sand. Almost entirely wood chips (brightly colored, not bleached or darkened with age, edges [illegible] indicating relatively recent origin).
4	300' due north of Kimberly-Clark discharge ditch	1,000	34	Bottom entirely paper mache. Considerable oil observed.
4a	500' north of Anna River mouth	500	32	Leaves, twigs, woody frass, small amount of sand. Oil [illegible] observed. *[illegible]*.
5	250' offshore of first point to the east	1,000	37	Fine sand and silt covered by wood chips and woody frass. Oils observed.
6	2,300' SW of second point to the east, edge of extensive sandy shoal area	4,000	22	Coarse sand with large quantities of bark and wood, and coal.
7	3,200' due north of Kimberly-Clark discharge	3,700	62	Black silty-muck, considerable wood chips and frass.
8	3,200' due north of coal pile	4,700	65	Brownish-red silt with some black silt intermixed. Abundant woody frass, some bark and coal.
9	1,200' NE of end of municipal dock	2,700	55	Brownish-red silt, small amount of coarse sand, [illegible] woody frass, some bark and coal.
10	1,700' due north of Kimberly-Clark discharge	2,000	53	Brown silt. Abundant wood chips, highly colored [illegible] rough edges. Considerable wood frass. Oils [illegible]
11	2,000' due north of Anna River mouth	2,000	56	Brown silt. Abundant woody fibres.
13	300' off shore of fishing boat docks, west shore	6,200	26	Bark and sand.
14	500±' off public boat launching site	6,500	22	Reddish-brown silt. Abundant *Nitella*.
15	Mid bay due east of public boat launching site	5,000	85	Red silt, some woody frass.
16	Mid bay, north of station 15	7,500	90	Red silt, some woody frass.
17	1,000' west of East Munising Point	6,000	80	Reddish-brown silt, some coarse sand. Bark and debris buried in silt.
18	Just off East Munising Point	6,500	33	Sand covered with woody frass and plant roots.
19	Approximately 1,000' NNE of East Munising Point	9,000	25	Red clay and sand, small amount of bark and wood. Some *Chara*.
21	300' offshore, along NW shoreline	9,300	16	Red clay. Large quantity of buried wood chips and bark. Some *Chara*.
22	500' offshore, along NNW shoreline	11,600	35	Red clay, some fine sand. Considerable buried bark and wood chips. *Nitella*.
23	West of Powell Point, west channel of Grand Island Harbor	12,600	35	Clean sand.

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Table 3. Benthic animals found in quantitative bottom samples of the littoral zone, South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

	Station:	5a	6	3	1	2	5	1	10	14	12¹	19	21	22	23
	Depth(Ft):	37	35	30	32	32	27	28	33	27	28	25	26	15	9
Tolerance Status	Scientific name / Distance from Anna River(Ft):	500	1000	1600	1700	2700	5000	4700	6200	6300	6200	9300	9500	11000	[illegible]
[illegible]	Procladius [illegible]	64		440	11	16	17	30	86	20		96	104	16	*
[illegible]	Prodiamesa olivacea	16			5										
[illegible]	Oligochaeta	160		400	64	160	80	160	80	76	O	80	144	47	—
[illegible]	Limnodrilus hoffmeisteri	104		1056			48			12	O	64		11	P
[illegible]	Pisidium sp.			48		64	16	64	20	64	O	22	64	16	*
[illegible]	Naididae				48			48							17
[illegible]	Asellus militaris ²					16	64	52	18	100	VA		16	111	
[illegible]	[illegible]					6									
[illegible]	Hexagenia limbata					6			6	8		*			
[illegible]	[illegible]					16			6					6	
[illegible]	[illegible]					132	64	176					104	21	
[illegible]	[illegible]					56									
[illegible]	Heterotrissocladius [illegible]						11	56	9	8	C	19	16	64	128
[illegible]	Pontoporeia affinis						5	6		8		10	8		
[illegible]	Amnicola sp.						5								
[illegible]	[illegible] sp.						16					22	32		
[illegible]	Dalyellia ? sp.						11				A		8		
[illegible]	Gammarus fasciatus						5					6		6	
[illegible]	Cladocera						5	6		6	P	7		6	
[illegible]	Brillia sp. ³						5								
[illegible]	[illegible]						9		128		P	48			
[illegible]	Hydrobaenus [illegible]							4		6				6	
[illegible]	Glossiphonia [illegible] ³							6	4	24		10	8	7	
[illegible]	Valvata sincera							6		20			24	40	
[illegible]	Hyalella azteca							16	17	76		7	16	7	*
[illegible]	Tendipedidae (pupae)							8							
[illegible]	Polypedilum halterale							24		20		16	16	27	
[illegible]	Calopsectra [illegible]								4		A				
[illegible]	Spongilla fragilis								5			5			C
[illegible]	[illegible] sp.								5						
[illegible]	Hydracarina								5						39
[illegible]	Ceratopogonidae								21					6	7
[illegible]	Pentaneura flavifrons								4						
[illegible]	Pseudochironomus sp.								9				8	9	
[illegible]	Harnischia amachaerus								8						
[illegible]	Cryptochironomus digitatus								6					11	2
[illegible]	Harnischia [illegible]								10						
[illegible]	Psectrocladius simulans								16						
[illegible]	Calopsectra dives								16	40	O		37	6	
[illegible]	Polypedilum sp.								4						
[illegible]	Nematoda								16	100	C	46		46	
[illegible]	Tubifex tubifex								10						
[illegible]	Limnodrilus sp.									16		7	8		
[illegible]	Glossiphonia stagnalis										P		4		
[illegible]	Physa sp.											33	12		
[illegible]	Stylaria fossularis											9	8		
[illegible]	Valvata tricarinata											2	8		
[illegible]	Mystacides sepulchralis											19			2
[illegible]	Harnischia [illegible]											3			
[illegible]	[illegible]											5			
[illegible]	Prodiamesa bathyphila												64		
[illegible]	[illegible] sp.												8		
[illegible]	[illegible] nr. sp. b (Roback)													4	
[illegible]	Lirceus sp.													11	
[illegible]	Helisoma sp.													4	
[illegible]	Copepoda													4	
[illegible]	Calopsectra sp.³													7	
[illegible]	[illegible] sp.													40	
[illegible]	Stylaria [illegible]														20
[illegible]	Stylodrilus heringianus														
	Total number of animals/sq. ft	559	0	1437	133	408	361	624	573	488	--	458	856	665	736
	Number of intolerant animals (I)	0	0	0	0	8	31	36	141	16	--	80	120	78	48
	Number of facultative animals (F)	0	0	0	48	244	105	288	106	152	--	164	400	212	102
	Number of tolerant animals (T)	559	0	1437	85	238	275	300	326	320	--	214	336	375	86
	Total number of species/sq. ft.	4	0	4	4	9	15	14	24	16	12	22	19	27	13
	Number of intolerant species (I)	0	0	0	0	2	3	1	3	2	3	5	4	2	1
	Number of facultative species (F)	0	0	0	1	3	7	8	14	6	3	10	10	15	8
	Number of tolerant species (T)	4	0	4	3	4	5	5	7	8	6	7	5	10	4

¹ Qualitative sample from several partial dredge hauls. Relative abundance of organisms is indicated by V(very abundant), A(abundant), C(common), O(occasional) and P(present).

² Characteristics intermediate between A. militaris and A. intermedius.

³ Not included in species compilations

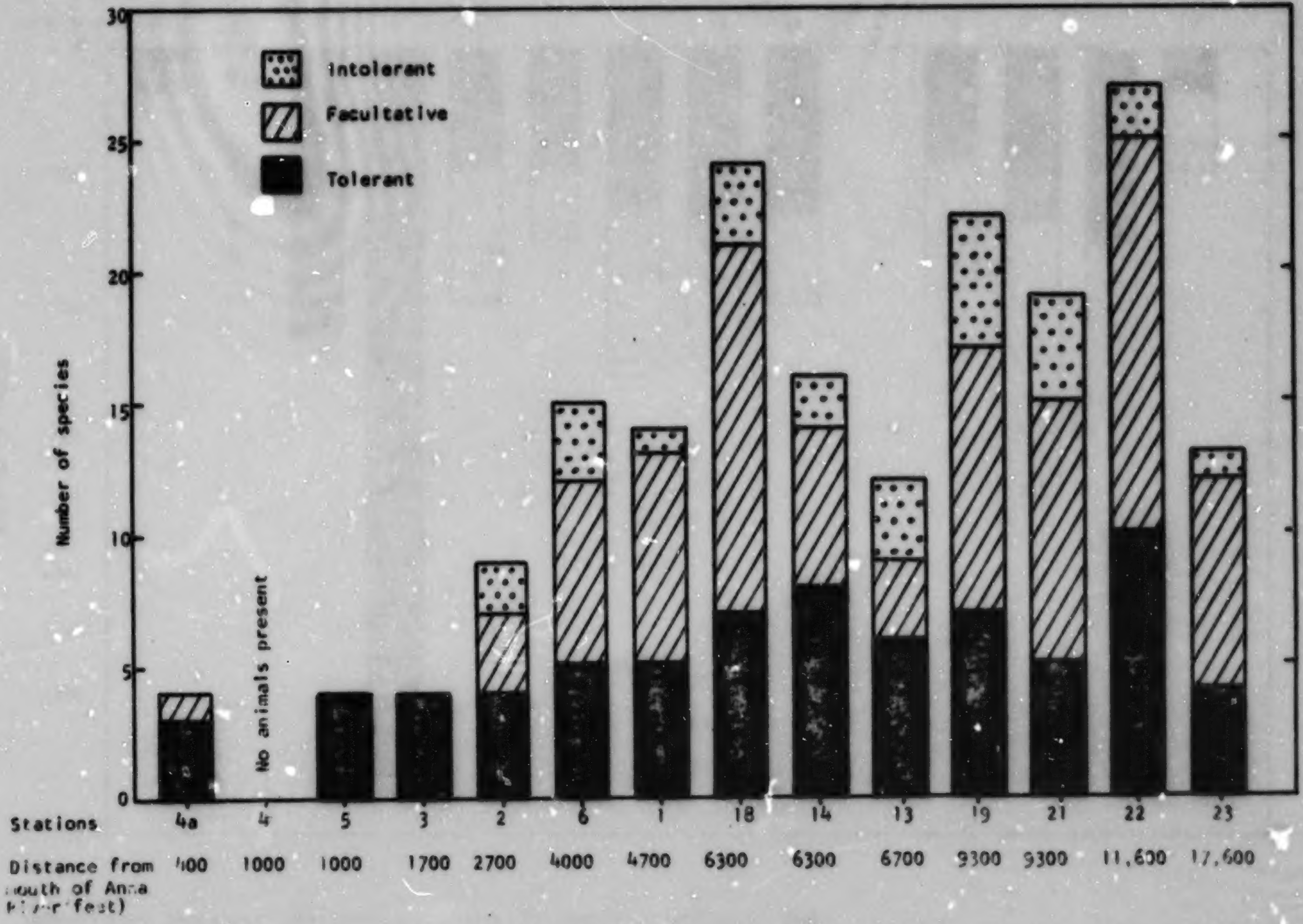


Figure 3. Number of benthic animal species and their tolerance status for fourteen quantitative littoral zone samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

Figure 4. Number of benthic animals and their tolerance status for fourteen quantitative littoral zone samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

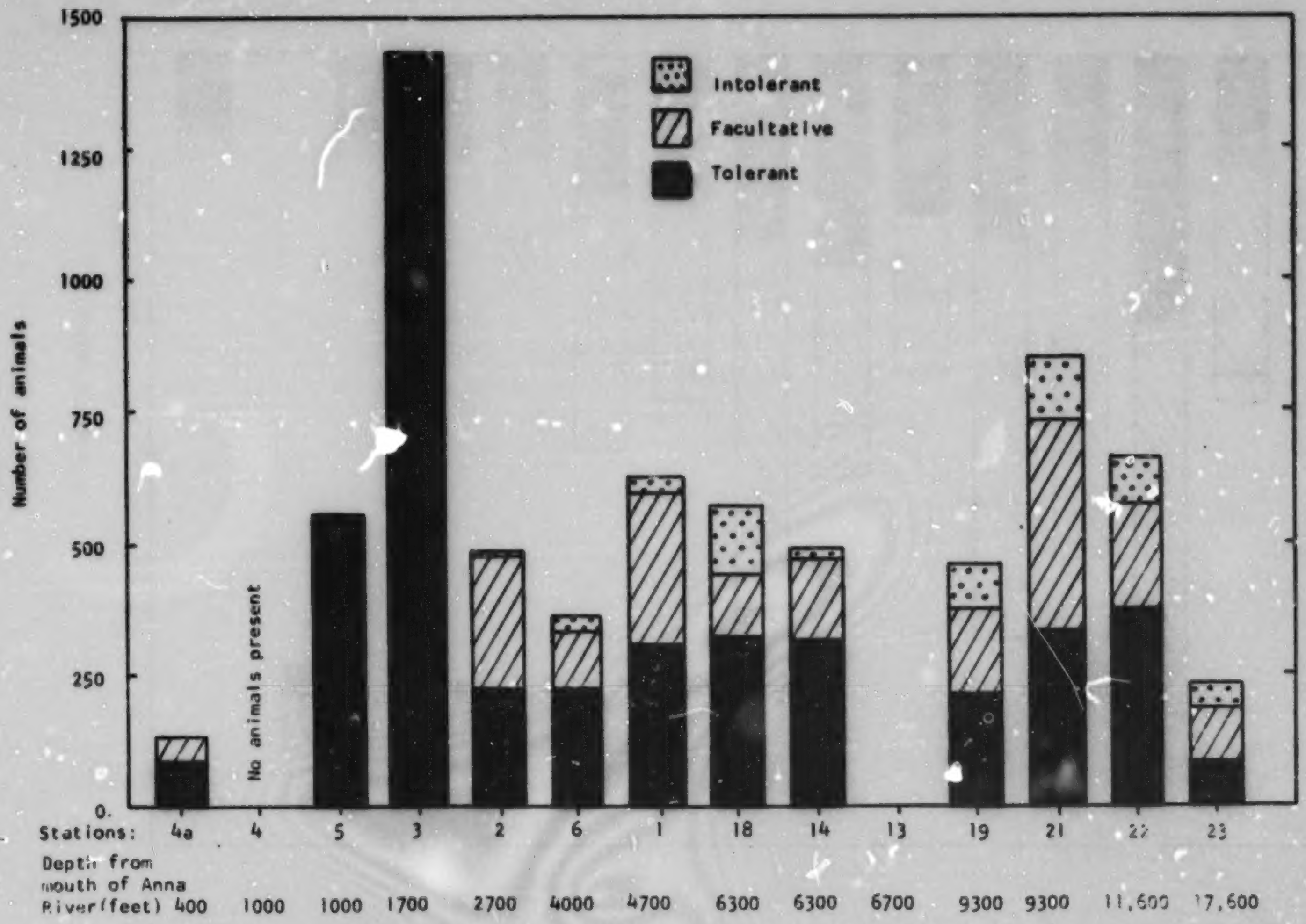


Table 4. Summary of biological data from quantitative littoral zone bottom samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968

	Stations													
Parameters	4a	4	5	3	2	6	1	18	14	13	19	21	22	23
Distance from mouth of Anna River (ft.)	400	1000	1000	1700	2700	4000	4700	6300	6300	6700	9300	9300	11,600	17,600
Depth of sample (ft.)	32	34	32	37	32	27	28	33	27	26	25	36	35	35
Total number of species/sq. ft.	4	0	4	4	9	15	14	24	16	12	22	19	27	13
Number of intolerant species/sq. ft.	0	0	0	0	2	3	1	3	2	3	5	4	2	1
Number of facultative species/sq. ft.	0	0	0	1	3	7	8	14	6	3	10	10	15	8
Number of tolerant species/sq. ft.	4	0	4	3	4	5	5	7	8	6	7	5	10	4
Total number of animals/sq. ft.	555	0	1432	133	488	361	624	573	488	-	458	856	665	236
Number of intolerant animals/sq. ft.	0	0	0	0	8	31	36	141	16	-	80	120	78	48
Number of facultative animals/sq. ft.	0	0	0	48	244	105	280	106	152	-	164	400	212	102
Number of tolerant animals/sq. ft.	559	0	1432	85	236	225	308	326	320	-	214	336	375	86
Percent intolerant animals/sq. ft.	0	0	0	0	2	9	6	25	3	-	17	14	12	21
Percent facultative animals/sq. ft.	0	0	0	36	50	29	45	18	31	-	36	47	32	43
Percent tolerant animals/sq. ft.	100	0	100	64	48	62	49	57	66	-	47	39	56	36
Biotic index	0	0	0	1	7	13	10	20	10	9	20	18	19	10
Diversity index	0.474	0.000	0.413	0.613	1.292	2.377	2.020	3.621	2.423	-	3.427	2.666	4.031	2.196

Table 5. Benthic animals found in quantitative bottom samples of the profundal zone, South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

Tolerance Status	Scientific name	Station:	10	11	7	9	8	15	17	16
		Depth(ft.):	53	56	62	55	65	85	88	90
		Distance from Anna River(ft.):	2000	2000	3700	2700	4700	5000	6000	7400
T	*Procladius adumbratus*		4	32	24				12	
T	*Asellus militaris* ?*		4			40	4	4		
T	*Pisidium* sp.		16		4	24	4	4		20
F	*Calopsectra dives*		16			8			4	
T	Oligochaeta		12	54		96	12			20
T	*Limnodrilus hoffmeisteri*		40	173				8		
I	*Pontoporeia affinis*				4	404	164	64	24	52
F	*Brillia* sp.?				4	64		12	4	4
F	*Valvata tricarinata*					8				
F	*Peloscolex ferox*					64	36			
F	Naididae					40				
F	*Valvata sincera*						4			
F	Tendipedidae (pupae)**						4			
F	*Tendipes anthracinus*							4	4	28
F	*Peloscolex* sp.							8		
T	*Tubifex tubifex*							8		
F	*Peloscolex multisetosus*									24
	Total number of animals/sq. ft.		92	259	36	748	228	112	48	148
	Number of intolerant animals (I)		0	0	4	404	164	64	24	52
	Number of facultative animals (F)		16	0	4	184	44	24	12	56
	Number of tolerant animals (T)		76	259	28	160	20	24	12	40
	Total number of species/sq. ft.		6	3	4	9	6	8	5	6
	Number of intolerant species (I)		0	0	1	1	1	1	1	1
	Number of facultative species (F)		1	0	1	5	2	3	3	3
	Number of tolerant species (T)		5	3	2	3	3	4	1	2

* Characteristics intermediate between *A. militaris* and *A. intermedius*

** Not included in species compilations

Figure 5. Number of benthic animal species and individuals and their tolerance status for eight quantitative profundal samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

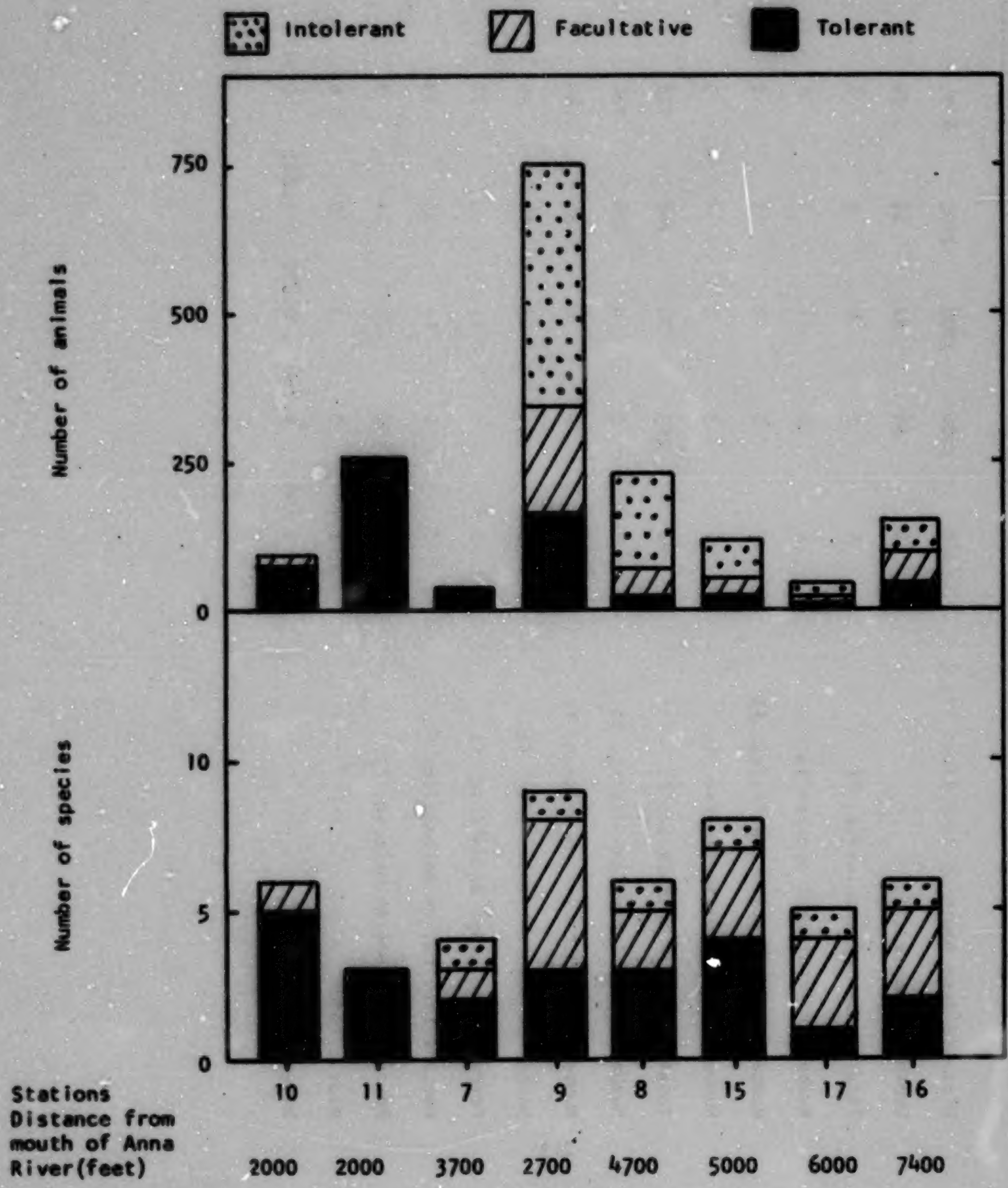


Table 6. Summary of biological data from quantitative profundal zone bottom samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

Parameters	Stations 10	11	7	9	8	15	17	16
Distance from mouth of Anna River (ft.)	2000	2000	3700	2700	4700	5000	6000	7400
Depth of Sample (ft.)	53	56	62	55	65	85	80	90
Total number of species/sq. ft.	6	3	4	9	6	8	5	6
Number of intolerant species/sq ft.	0	0	1	1	1	1	1	1
Number of facultative species/sq. ft.	1	0	1	5	2	3	3	3
Number of tolerant species/sq. ft.	5	3	2	3	3	4	1	2
Total number of animals/sq. ft.	92	259	36	748	228	112	48	148
Number of intolerant animals/sq. ft.	0	0	4	404	164	64	24	52
Number of facultative animals/sq. ft.	16	0	4	184	44	24	12	56
Number of tolerant animals/sq. ft.	76	259	28	160	20	24	12	40
Percent intolerant animals/sq. ft.	0	0	11	54	72	58	50	35
Percent facultative animals/sq. ft.	17	0	11	25	19	21	25	38
Percent tolerant animals/sq. ft.	83	100	78	21	9	21	25	27
Biotic Index	1	0	3	7	4	5	5	5
Diversity Index	1.106	0.360	0.837	1.209	0.921	1.483	1.033	1.001

Table 7. Summary of biological data from seven comparable littoral zone sampling stations, South Bay, Lake Superior, Munising, Michigan 1957 and 1968.

1968 Station Number	3		2		6		1		22		19		23	
Year of Sample	1957	1968	1957	1968	1957	1968	1957	1968	1957	1968	1957	1968	1957	1968
Total number of species/sq. ft.	4	4	19	9	14	15	14	14	20	27	19	22	13	13
Number of intolerant species	0	0	1	2	1	3	1	1	2	2	3	5	2	1
Number of facultative species	0	0	13	3	6	7	8	8	11	15	12	10	7	8
Number of tolerant species	4	4	5	4	7	5	5	5	7	10	4	7	4	4
Biotic index	0	0	15	7	8	13	10	10	15	19	18	20	11	10
Total number of animals/sq. ft.	212	133	717	488	1874	361	520	624	423	665	704	458	139	236
Number of intolerant animals	0	0	14	8	12	31	4	36	18	78	76	80	10	48
Number of facultative animals	0	48	110	244	15	105	116	280	114	212	301	164	34	102
Number of tolerant animals	212	85	593	236	1820	225	400	308	291	375	327	214	105	86

Figure 6. Number of benthic animal species and their tolerance status for seven comparable bottom sampling stations in South Bay, Lake Superior, Munising, Michigan, 1957 and 1968.

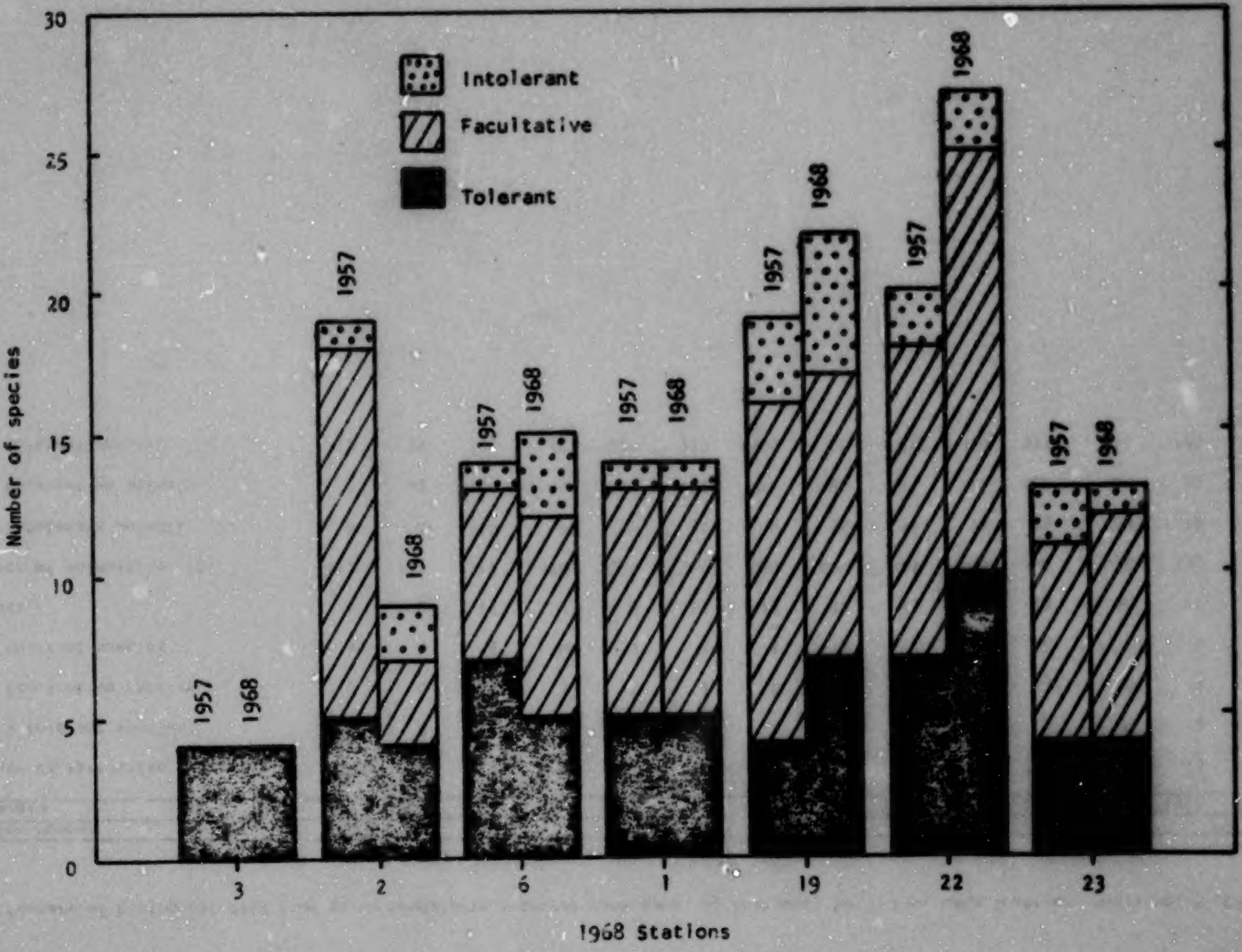


Table 8. Algal composition in qualitative and quantitative samples from South Bay, Lake Superior, Alger County, Michigan, August 6, 1968.

Mid bay Vicinity of benthic station 15			Inshore 200 yards off mouth of Anna River		
Plankton tow	Grab sample		Plankton tow	Grab sample	
Navicula	*Navicula*	17/ml	*Navicula*	*Navicula*	105/ml
Tabellaria	*Cymbella*	34/ml	*Tabellaria*	*Tabellaria*	70/ml
Cymbella	Total	51/ml	*Fragilaria*	*Asterionella*	105/ml
			Asterionella	Total	280/ml

Table 9. Selected water quality parameters measured in grab samples from South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

Station	Location	Temperature C°	BOD mg/l	Suspended Solids mg/l	pH
1	50 yards offshore, 50 yards west of Kimberly-Clark outfall	66	1	2.1	7.0
2	Kimberly-Clark effluent	86	>20	21.0	6.7
3	50 yards offshore, 50 yards east of Kimberly-Clark outfall	73	12	7.0	6.9
4	mouth of Anna River	57	7	14.8	6.9
5	50 yards east of Anna River, 50 yards offshore	70	12	7.0	6.8
6	200 yards offshore, north of station 5	66	2	4.4	6.8
7	200 yards offshore from Kimberly-Clark outfall	66	<1	5.6	6.8
8	Anna River, M-28 bridge	--	--	----	6.9

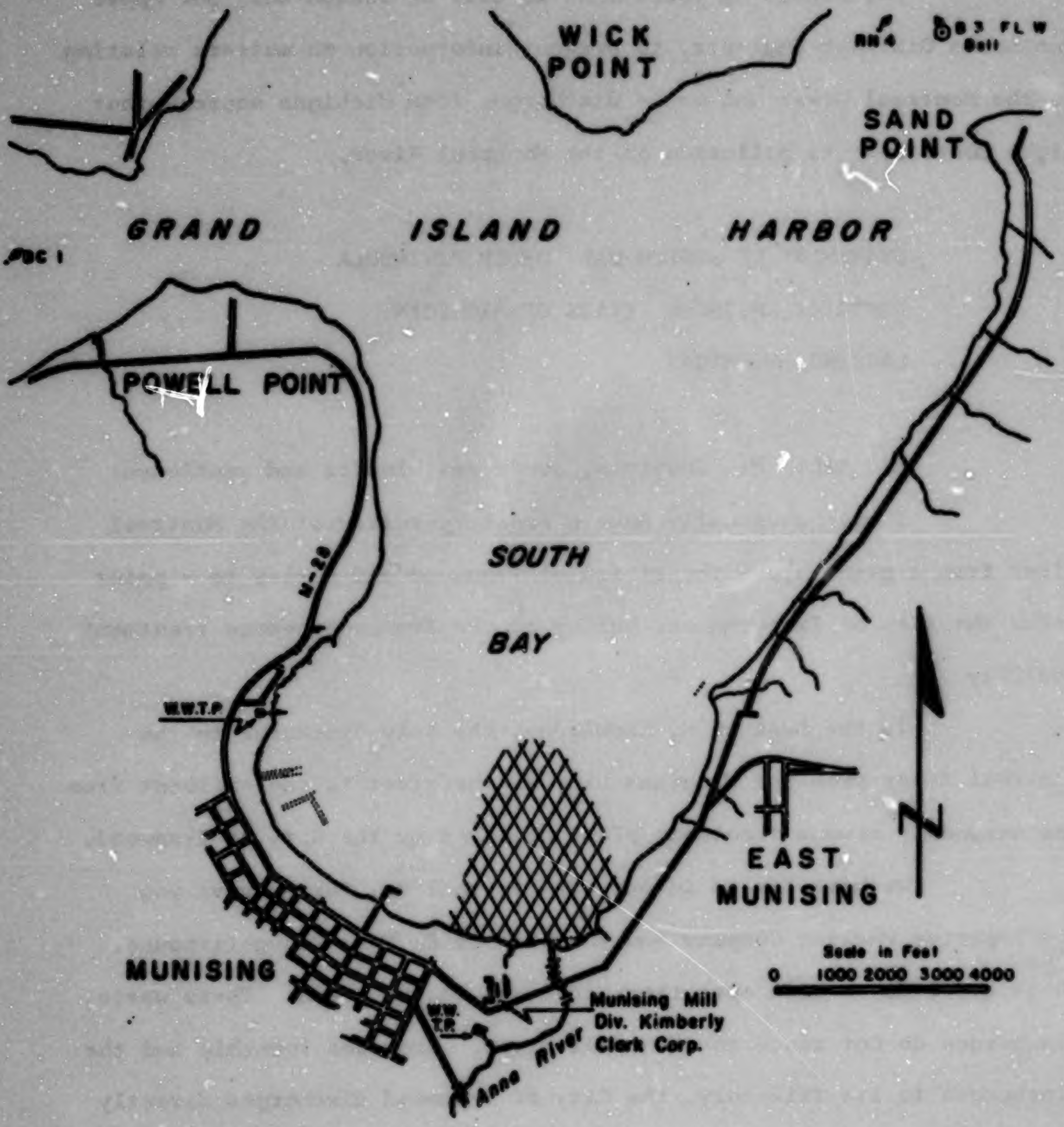
Table 10. Dissolved oxygen profiles of South Bay, Lake Superior, Munising, Michigan August 6, 1968.

	Inshore 900' north of K-C discharge		Midbay vicinity of benthic station 15	
Depth(feet)	Dissolved oxygen mg/l	Temperature C	Dissolved oxygen mg/l	Temperature C
Surface	10.4	66	10.0	63
10	10.4	--	10.6	--
20	11.0	--	10.8	--
30	10.6	--	11.2	--
40	10.8	61	11.2	--
50	----	--	11.6	--
60	----	--	11.2	--
70	----	--	11.0	52

Table 11. Average biotic index, diversity index, and number of species found in portions of South Bay, Lake Superior, Munising, Michigan, August 6, 1968.

	$\bar{X}$ Biotic index	$\bar{X}$ Diversity index	$\bar{X}$ Number of species
Littoral zone of degradation (Stations 3,4,4a,5)	0.25	0.375	2.75
Inner bay-littoral zone (Stations 1,2,6,13,14)	9.80	2.028	13.20
Outer bay-littoral zone (Stations 18,19,21,22,23)	17.40	3.188	21.00
Profundal zone of degradation (Stations 7,10,11)	1.33	0.768	4.33
Profundal zone (Stations 8,9,15,16,17)	5.20	1.129	5.80

Figure 7. **South Bay, Lake Superior Zone of Benthic Degradation August 6, 1968**


WICK POINT
RN 4
B 3 FL W Bell
SAND POINT
GRAND ISLAND HARBOR
PBC I
POWELL POINT
M-28
SOUTH BAY
W.W.T.P.
EAST MUNISING
MUNISING
W.W. T.P.
Munising Mill Div. Kimberly Clark Corp.
Anna River
Scale in Feet
0 1000 2000 3000 4000

Joseph Bal

MR. PURDY: I would like to call on Joseph Bal, our Upper Peninsula District Engineer, to present information on matters relating to the Montreal River and waste discharges from Michigan sources that might contribute to pollution of the Montreal River.

STATEMENT OF JOSEPH BAL, UPPER PENINSULA
DISTRICT ENGINEER, STATE OF MICHIGAN,
LANSING, MICHIGAN

MR. BAL: Mr. Chairman, conferees, ladies and gentlemen:

I have personally made a sanitary survey of the Montreal River from a point above the cities of Ironwood and Hurley to a point below the city of Ironwood and Hurley at the Ironwood sewage treatment facility.

To the best of my knowledge, the only discharge to the Montreal River from the Michigan side of the river is the effluent from the secondary sewage treatment plant operated by the City of Ironwood.

We have listed in our summary that Mr. Turney gave you the Superior Packing Company and the William E. Maki Slaughterhouse. These are 1-day-a-week operations that are in the basin. These waste discharges do not reach the Montreal River. Ironwood Township and the discharges to its tributary, the City of Ironwood discharges directly to the river; Erwin Township had a septic tank with a drain field.

MR. PURDY: I will call on Mr. Courchaine to give information with respect to the quality of the discharge from the Ironwood wastewater treatment plant.

Do we have any questions of Mr. Bal?

MR. DOMINICK: Mr. Frangos.

MR. FRANGOS: Mr. Bal, were you able to reach any conclusions with respect to any pollution sources from the Wisconsin side of the Montreal River?

MR. BAL: No, sir, I did not. This was a sanitary survey merely to find out what was being discharged from our side of the river.

MR. FRANGOS: Thank you.

MR. PURDY: I would like to call on Mr. Cletus Courchaine of the Upper Michigan Office of the Michigan Department of Public Health.

STATEMENT OF CLETUS COURCHAINE,
UPPER MICHIGAN OFFICE, MICHIGAN
DEPARTMENT OF PUBLIC HEALTH,
ESCANABA, MICHIGAN

MR. PURDY: Mr. Courchaine, in your capacity in charge of the Upper Peninsula office of the Michigan Department of Public Health you receive operating reports from the City of Ironwood with respect to the operation of their wastewater treatment facility. On the basis of this report, could you describe the degree of treatment and effluent quality from this treatment plant?

MR. COURCHAINE: Yes, I will.

I would like to call your attantion to Appendix H and Appendix J.

Cletus Courchaine

Appendix J. first, presents typical data on the activated sludge plant at Ironwood. This is the only plant that discharges directly into the Montreal River. The plant is operated by a person certified as to competency by our Department. He is a Class B operator, which is the class of this plant.

Approximately 90 percent of the BOD is removed on a year-round basis from this facility.

In Appendix H I have data, bacteriological data. This is on Page 85. The arithmetic average for the data presented is 317, and the tests are by the Millipore method.

Mr. Chairman, I have additional information on bacteriological quality from this plant and if it is satisfactory, I would like to present this.

I have additional bacteriological data from this plant, Mr. Chairman, and I would like to present it if it is satisfactory.

MR. DOMINICK: That will be accepted for the record.

(The above-mentioned table follows:)

5-8-69

Bacteriological Data
Wastewater Treatment Plant Effluent
Ironwood, Michigan

April 1968 - March 1969

1968

Apr. 2 - 1500
9 - 800
15 - 200
22 - 400
29 - 900

May 7 - 800
13 - 200
20 - 1500
27 - 800

June 3 - 400
4 - 1000
10 - 400
17 - 100
24 - 100

July 2 - 200
8 - 300
11 - 200
17 - 100
21 - 300
29 - 200

Aug. 5 - 100
12 - 200
14 - 200
21 - 400
27 - 100
28 - 200

Sept. 2 - 200
5 - 800
11 - 100
16 - 300
19 - 300
25 - 800

Oct. 2 - 900
7 - 200
14 - 400
23 - 100
28 - 800

Nov. 3 - 900
6 - 300
7 - 200
12 - 100
14 - 200
27 - 200

Dec. 3 - 200
6 - 300
9 - 900
11 - 500
14 - 300
19 - 200
23 - 300
30 - 400

1969

Jan. 6 - 2500
7 - 1500
8 - 600
13 - 200
15 - 600
20 - 500
27 - 500
30 - 800

Feb. 3 - 1200
10 - 800
17 - 200
20 - 100

Mar. 3 - 800
6 - 300
10 - 700
19 - 100
24 - 800
26 - 200

MR. COURCHAINE: To summarize this data, it is a year's bacteriological data, and it shows 69 samples. The samples range between 100 and 2,500, and there are just five over 1,000 coliform per 100 ml. The arithmetic average of those is 490 coliform per 100 ml.

I would be happy to answer any questions if you have any.

I consider this a very well operated activated sludge plant.

MR. DOMINICK: Thank you.

Are there any questions?

(No response.)

MR. DOMINICK: Thank you very much.

MR. PURDY: At this time I would like to call upon Asa Wright for a statement on behalf of Dr. Ralph MacMullan, the Director of the Department of Natural Resources.

STATEMENT OF DR. RALPH A. MACMULLAN,
DIRECTOR, DEPARTMENT OF NATURAL
RESOURCES, STATE OF MICHIGAN,
LANSING, MICHIGAN, (READ BY MR. ASA WRIGHT)

MR. WRIGHT: Mr. Chairman, conferees:

On behalf of Dr. Ralph MacMullan I would like to read the following statement and have it recorded in the minutes of this conference.

MR. DOMINICK: That will be received.

Dr. Ralph MacMullan

MR. WRIGHT: The statement reads as follows:

The waters of Lake Superior are believed to be as pristine in nature as any waters might be in this age of technological advance and human population explosion. We deplore any form of effluent discharge into these waters, or any discharge of foreign materials that result in shoreline changes or bottom deposits that are, or may become, injurious to water quality or aquatic life.

Some of the problems we have seen in the past have been: (1) discharges of brines, and suspended and settleable solids from mine operations; (2) inputs of persistent pesticides, deposition of fibrous organic mats, discharges of toxic liquors and highly colored wastes from a variety of agricultural and industrial operations; (3) releases of heated wastewater from manufacturing and electric power generating plants; and (4) discharges of untreated or inadequately treated human wastes.

Interstate water quality standards have been proposed and adopted by the State of Michigan for the waters of Lake Superior. We believe that all water control agencies would be derelict to permit degradation of Lake Superior waters, even down to these standards. The State of Michigan has a fine pollution control law and a strong Water Resources Commission, and I am confident that this Commission, working with the Department of Natural Resources, will fully implement our water quality program and enforce the provisions of our Water Resources Commission Act. To this end, the electorate of Michigan have indicated their concern for clean water through the passage of a $335 million bonding program to assist in financing municipal waste treatment facilities.

B. Dale Ball

Rehabilitation of the sport and commercial fisheries of Lake Superior is currently under way, at considerable expense to the bordering States, the Province of Ontario, and the Canadian and United States Governments. This expense will be justified by the tangible and intangible benefits which are even now being realized. Any activities which tend to depreciate water quality or have a harmful effect upon the aquatic environment must be held to be improper and in conflict with the public trust in the waters of Lake Superior, and in violation of the Michigan Water Resources Act.

That concludes the statement.

MR. DOMINICK: Are there any questions?

MR. FRANGOS: Mr. Chairman, may we have copies of that statement? Are they available?

MR. PURDY: We will make copies and distribute them to the conferees later in the day.

MR. WRIGHT: There were copies made.

MR. PURDY: Fine. Thank you.

I now have a statement to present on behalf of B. Dale Ball, Director, of the Department of Agriculture. Again, we will make copies and have them available for the conferees and the reporter.

STATEMENT OF B. DALE BALL, DIRECTOR
DEPARTMENT OF AGRICULTURE, STATE OF
MICHIGAN, LANSING, MICHIGAN, (READ
BY RALPH PURDY.)

B. Dale Ball

MR. PURDY: It is addressed to The Honorable Walter J. Hickel.

Gentlemen: May 6, 1969

The Michigan Department of Agriculture is very much involved in the management of Michigan Natural Resources, including the resource which is the subject of this conference.

The Director of Agriculture is a member of the Michigan Water Resources Commission, the Air Pollution Control Commission, and is the Chairman of the State Soil Conservation Committee. The Director of Agriculture is also Chairman of the Drainage Boards for the more than 1,000 established intercounty drains within the State. I cite this to illustrate the extent of the Department's responsibility and commitment to the management of the State's natural resources.

In considering the subject of this conference and its relation to agriculture, it must be recognized that agriculture, as an industry within the Michigan portion of the Lake Superior Basin, is very limited.

There are three aspects of agriculture which may be of concern in the matter of water pollution. They are, sedimentation, nutrients from fertilizers and animal wastes, and agricultural pesticides. We are not aware that any of these constitute a pollution problem in the Michigan waters of Lake Superior as a result of agriculture in the Michigan portion of the Lake Superior Basin.

Agriculture has repeatedly demonstrated an eager willingness to accept newly developed materials and techniques scientifically tested for the control of soil erosion, plant and insect pests, and the efficient use of crop nutrients.

The facts are conclusive that Michigan is taking aggressive action in the conservation of our water resources.

Our pesticide research facilities are among the most advanced in the world.

The Michigan Department of Agriculture has taken timely action to reduce the unnecessary use of the hard pesticides.

I might amplify on this, in that Mr. Ball is speaking on the action taken by the Department of Agriculture to ban the sale of DDT in the State of Michigan.

(Continued reading.)

Soil Conservation districts are carrying out an active program in soil and water management throughout the State.

Legislation is now being enacted in the State to implement a $335 million bond issue for public waste disposal facilities.

The Michigan Water Resources Commission is now carrying out, and will continue to carry out, a comprehensive program of pollution abatement to protect and preserve the quality of water of Lake Superior.

We are of the opinion that the State of Michigan is undertaking measures that are wholly adequate to abate and prevent the pollution of the waters of Lake Superior and its tributary basin and that there are no delays being encountered in the measures being undertaken by the State of Michigan.

This now completes the statements to be presented by State agencies, and I would now like to present the conclusions from

Page 45 of our report.

STATEMENT OF RALPH W. PURDY, EXECUTIVE SECRETARY, MICHIGAN WATER RESOURCES COMMISSION, LANSING, MICHIGAN

MR. PURDY: The citizens and government of Michigan are very keenly aware of the value of clean water, both in Lake Superior and in inland lakes and streams. The people have supported and the State government has developed broadscale and fast-moving programs of pollution control.

Michigan law provides a full and effective statutory basis for preventing and controlling pollution. The State Legislature has repeatedly shown its willingness to enact additional laws as the need for them emerges.

Through its Water Resources Commission, its Department of Public Health and its Geological Survey, Michigan has an aggressive, effective and large-scale program of water pollution control in active operation. The Michigan plan for effectuating this program in 1968-1969 has been fully approved by the Secretary of the Interior.

The State has an ongoing and appropriately expanding program of waste disposal surveillance and water quality monitoring which is fully responsive to the needs for detecting and identifying its pollution problems.

The Water Resources Commission and Department of Public Health have amply demonstrated that when pollution problems are identified they can and do take proper corrective action.

The State Legislature has responded to Executive requests for successive increases in State expenditures for pollution control.

Michigan's $355 million clean water bond proposal was approved in November 1968 by Michigan voters by a 2 to 1 margin. This bond program when fully implemented will provide substantial grant assistance to municipalities and townships for the construction of sewage treatment works and for construction of sewer systems to correct improper sewage discharges.

The Water Resources Commission has adopted water quality standards for all waters, together with a plan for implementation and enforcement of the interstate standards.

Michigan has only one small municipal wastewater discharge and one industrial and two electirc power generating plants which make a direct discharge of wastewaters to Lake Superior. These discharges have only a minor effect on water quality in the immediate area of discharge and, with the exception of the municipal discharge, are considered to have no pollutional effect on the waters of Lake Superior.

In accordance with the Commission's plan of implementation of its interstate water quality standards, correction of the municipal discharge will be accomplished on or before June 1, 1972.

There are four coastal communities with a combined 1960 population of approximately 29,000 which discharge primary treated and chlorinated effluent into intrastate waters. Again, with the exception of minor effects on water quality in the immediate river

river mouth areas, these discharges have not been determined to have a pollutional effect on the waters of Lake Superior, except for the phosphorus nutrients added to the lake waters.

One industrial discharge into intrastate waters, near the mouth, has been determined to result in occasional taste and odor problems in a Lake Superior community water supply. A corrective program is being pursued with this industry and it is fully expected that a timely schedule will be developed for an early solution to the problem.

The Michigan agencies recognize the pollution problems on waters tributary to Lake Superior and have in operation aggressive programs for their full and timely correction. The present deficiencies in waste treatment at inland locations do not contribute to pollutional conditions in Lake Superior except as a residual phosphorus loading carries on down to the lake.

The Water Resources Commission recognizes the phosphorus problem in accelerating stream and lake water enrichment and has adopted a State-wide policy and comprehensive program for phosphate removal from waste discharges, with scheduled early completion dates.

In addition to the conclusions that we have presented as a part of the report, we have presented additional information with respect to waste discharges to the Montreal River from Michigan sources. We believe that the additional information substantiates our conclusions that Michigan sources have provided adequate treatment of waste discharges to this interstate river.

The details of the report also show the action that the

Michigan Water Resources Commission has taken to prevent the discharge of tailings into inter- or intrastate waters. This will show that one mill that disposes of approximately 25,000 tons per day of tailings discharges these tailings to on-land disposal site with overflow water. The other tailings disposal operation within the Lake Superior Basin has an entirely closed system.

Do you have any questions on the statement of our conclusions?

MR. DOMINICK: Are there any questions?

MR. BADALICH: Mr. Chairman, Mr. Purdy, referring to Page 46, what is the degree of removal of phosphates that you referred to in your last paragraph?

MR. PURDY: We have asked for a minimum of 80 percent total phosphorus removal.

MR. BADALICH: Thank you.

MR. PURDY: The outside date is June 1, 1977. If a new plant is constructed or an existing plant is expanded, phosphorus removal facilities must be constructed as a part of the construction program.

MR. DOMINICK: Mr. Stein.

MR. STEIN: Mr. Purdy, you talk about your programs for the full and timely corrections. Do I assume that you do, as you have in other parts of the State, have orders issued against sources of pollution and stipulations on file with the Commission to secure remedial action?

MR. PURDY: We do not have this in all cases at the present time, but if those are not received, such action will be taken by the Commission.

MR. STEIN: The question is you don't have orders on it as yet?

MR. PURDY: No.

MR. DOMINICK: I think that Mr. Stein is reading from the second to the last paragraph in your conclusions. Have you set out in your report anywhere in the index a listing of your correction schedules and a listing of those instances where orders are now outstanding?

MR. PURDY: Yes, the appendices to the report include all formal actions. In addition to that we have included outside dates for correction, i.e. the municipal problems to be corrected by June 1, 1972; the industrial problems to be corrected by 1970; and, if we do not have programs established in advance of those dates, the Commission will take action to establish them.

MR. DOMINICK: Very good. Thank you.

Are there any other questions?

(No response.)

MR. PURDY: I now have a statement to present on behalf of Senator Thomas Schweigert, President of the Michigan State Senate.

MR. DOMINICK: It will be made a part of the record.

(The above-mentioned letter was read and follows.)

MR. PURDY: I have a statement on behalf of the Michigan United Conservation Clubs, by James L. Rouman, Executive Director.

I have copies that I can distribute to the conferees and

THE SENATE
LANSING, MICHIGAN

THIRTY-SEVENTH DISTRICT
THOMAS F. SCHWEIGERT
[illegible] EAST MITCHELL
PETOSKEY, 49770

PRESIDENT

RECEIVED
MAY 1[illegible] 1969

To: Mr. Ralph Purdy
Water Resources Commission

Date: May 9, 1969

Statement of Senator Thomas F. Schweigert, President of the Michigan State Senate:

Alerted by longtime pollution which has rendered Lake Erie a "dead lake" and more recent evidences of growing serious pollution problems of Lake Michigan, residents of Michigan last November approved a $335 million bond issue with which to combat pollution.

Of that amount, $285 million will be used to construct sewage treatment plants around the State.

The Legislature has just completed determining how the money should be allocated. Primarily, it will be handled under the direction of the Water Resources Commission.

We were disappointed because the Federal government did not come through with what had been expected in matching funds and it appears we are going to have to bear most of our burden alone even though use of the five Great Lakes transcends Michigan's problems.

Up to now, we have not been greatly perturbed about pollution in Lake Superior. But we have learned from Lake Erie, which appears beyond redemption, and Lake Michigan, which is rapidly approaching a point where it will be impossible to reverse the encroachment of pollution.

So, while we fully recognize the economic importance of the mining industry to Minnesota and Michigan, we stand ready to do all in our power to prevent damage to the magnificent Lake Superior.

We sincerely hope that the mining companies and other industrial users of Lake Superior can be encouraged to speed up pollution controls in their operations to insure Lake Superior against the same fate that has struck Lake Erie and that is rapidly polluting Lake Superior.

TFS:mes

to the reporter, and I ask that it be placed in the record.

(The above-mentioned statement follows.)

MR. STEIN: Mr. Purdy, while you are doing that, I wonder if I would go back to the original statement.

You talk about phosphate removal. What percent are you--

MR. PURDY (interrupting): Eighty percent total as a minimum.

MR. STEIN: As a minimum?

MR. PURDY: Yes.

MR. STEIN: The control conference recommended well over 90 percent.

MR. PURDY: Yes, sir.

I have a statement of White Pine Copper Company by E. R. Bingham, Director of Quality Control. I would like to read this statement into the record because it points out the waste control operations of a very important mining operation in Michigan.

(The above-mentioned statement was read and follows.)

MR. PURDY: I also have a statement by the National Audubon Society, Edward M. Brigham III, Regional Representative.

(The above-mentioned statement was read and follows.)

I have an additional statement by Mr. W. L. Robinson, a member of the Steering Committee of the Citizens to Save the Superior Shoreline.

(The above-mentioned statement was read and follows.)

I have a request from George G. Mallinson, Dean, Western Michigan University School of Graduate Studies, to present a statement.

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STATEMENT OF MICHIGAN UNITED CONSERVATION CLUBS

By: James L. Rouman, Executive Director

Federal Conference on Pollution of Lake Superior and Tributary Basin

Duluth, Minnesota - May 13, 1969

Michigan United Conservation Clubs is a statewide citizens' organization of 350 affiliate clubs with total membership of 106,000. State headquarters are at 1120 East Oakland Avenue, Lansing, Michigan. MUCC publishes a monthly tabloid magazine, MICHIGAN OUT-OF-DOORS, which is mailed to all members.

We in MUCC are concerned with all aspects of natural resources management, environmental quality, conservation education and outdoor recreation. Therefore we welcome this opportunity to present our statement in regard to pollution of Lake Superior and its tributary basin.

MUCC has for many years been concerned with the control of all forms of pollution. We recognize that Lake Superior is a very unique part of the Great Lakes system and we are hopeful that every effort will be made to eliminate sources of pollution so that no degradation will take place.

"STATEWIDE"

"To Further and Advance Conservation in All of Its Phases"

MUCC has enjoyed an exceptionally fine cooperative relationship with the Michigan Water Resources Commission, particularly during the past several years when this State has been involved in the setting of inter and intra-state water quality standards. We also are keenly interested in legislative efforts to provide for financing of pollution control measures, and accordingly played a major role in promotion of the $335 million clean water bonding program and the $100 million recreation bonding program approved by Michigan voters in November, 1968.

Another significant item of anti-pollution effort as far as Michigan is concerned involves the efforts of several legislators to allow Upper Peninsula mining companies to dewater mines in the Upper Peninsula. A recent session of the legislature had amended the Water Resources Act in such a way as to exclude copper and iron mining operations from its provisions. Subsequently the Water Resources Commission received an application to permit the use of Hill Creek -- a small but fairly important trout stream in the Upper Peninsula -- by the Calumet and Hecla Mining Company for the disposal of waters containing extremely high concentrations of chloride from its mine in Houghton County. If permitted, this dewatering would have completely destroyed for many years the fish and wildlife abounding in this stream which flows into Lake Superior. In an opinion issued on January 27, 1969, Attorney General Frank J. Kelley made the fullest use of Art. 4, Sec. 52 of the Constitution of 1963, which declared the state's public policy to be that the air, water and other natural resources of the state were to be protected from pollution, impairment and destruction, and enjoined the legislature to pass laws to that effect. Consequently, Attorney General Kelley ruled that the legislature could not by exclusion of particular industries in effect permit pollution of the waters of the state and thus violate the mandate of the Constitution.

Michigan United Conservation Clubs had been in communication both with the Attorney General Department and the Water Resources Commission in regard to this situation and we were much gratified by the opinion which upheld our position that the waters of Hill Creek and ultimately Lake Superior should not be degraded by the disposal of mining wastes. On February 9, 1969 the MUCC Board of Directors passed a resolution commending Attorney General Kelley "for his courage in approving the recent opinion regarding prohibiting use of the waters of Hill Creek for the disposal of liquid mine wastes."

We in MUCC believe that due to the joint cooperative efforts of our state agencies and alert citizens' organizations, Lake Superior has thus far been fairly well protected from pollution emanating from sources in this state. It is our sincere hope that efforts by all agencies and organizations will continue to improve and additional anti-pollution measures will be taken to keep Lake Superior as clean as possible.

MUCC as the leader of citizens' conservation organizations in this State will continue its active interest to this end.

We respectfully request that this statement be made a part of the official conference record.

James L. Rouman

James L. Rouman
Executive Director

WHITE PINE COPPER COMPANY
A SUBSIDIARY OF COPPER RANGE COMPANY

WHITE PINE, MICHIGAN
49971

[illegible]
AREA CODE [illegible]

May 13, 1969

Statement on behalf of the White Pine Copper Company, White Pine, Ontonagon County, Michigan, at the Conference on Pollution of Lake Superior, Duluth, Minnesota, May 13, 1969. By: E. R. Bingham, Director of Quality Control, White Pine Copper Company.

Gentlemen:

White Pine Copper Company, a wholly-owned subsidiary of Copper Range Company, New York City, operates a copper mine, mill and smelter in Ontonagon County in Michigan's Upper Peninsula. The minesite is located about five miles from Lake Superior, mostly in Section 4, T 50 N, R 42 W.

As an integrated primary copper producer, the plant generates the following wastes that could conceivably affect the quality of the designated receiving water, the Mineral River.

1. Approximately 24,000 TPD of finely ground silicious mill flotation tailings.
2. Sewage and waste water from the adjacent townsite and the plant in a quantity representing a total population of about 2,500 persons.
3. Miscellaneous wastes from the operation including ash blowdown from a coal-fired steam power plant, accidental oil spills, tailings spills resulting from equipment malfunction, and storm runoff water from the plantsite area.

Control and Treatment

1. Mill Tailings - This material is pumped to an impoundment area where the solids are settled out prior to decanting the carrier water to the natural drainage.

   This discharge has been regulated by an Order of Determination from the Michigan Water Resources Commission, first issued on October 26, 1955, under the authority of Michigan PA245 - 1929.

This Order designates the Mineral River as the receiving water, limits the discharge to 16,000 GPM maximum, and sets specific limits on turbidity (30 ppm), suspended solids (25 ppm), and pH (7.5 to 10.4). Further, the Order contains a general prohibition against any chemical substance which would render the waters unsuitable for domestic, commercial or industrial water supply uses, or would be toxic to humans, animal, fish, or other aquatic life forms.

In implementing the water quality standards set in 1967 under U.S. PL 84-660, the Mineral River was further protected for intolerant fish, warm water species, and for anadromous fish migration.

The clarified water is decanted from a single point inside the tailings impoundment. A simple wierboard arrangement allows the flow to be shut off when wind conditions cause roiling to the point where the turbidity limit is approached. The outflow remains closed until the water clarifies.

Because of the control measures used on this effluent and the very high inherent purity of the tailings water decanted, the company has always received a Class "A" rating in the Michigan Water Resource Commission's annual review of the state's industries.

2. Sewage and Waste Water - The main plant and townsite sewage effluent has secondary treatment plus chlorination, in a plant designed for a 900,000 GPD input. The average flow through the plant is 300,000 GPD. As with the tailings effluent, the Mineral River is the designated receiving water.

Secondary treatment is also provided at two outlying mine shafts by means of appropriately sized package treatment plants.

These plants, maintained by two licensed operators plus other personnel, meet the present state requirements in every way.

In accordance with a directive received from the Michigan Water Resources Commission on 2/5/68, plans are in progress for the removal of phosphorous compounds from the main sewage plant effluent. At present, analytical data and flow rates are being compiled for the engineering and design to follow. The target date for installation of a system is the summer of 1971.

3. Miscellaneous Waste Water System - The drainage from the immediate plant site area empties into Bedell Creek which flow north two miles to its confluence with the Mineral River. A check dam holding 5 million gallons has been placed just downstream from the plant with a system designed to lift substandard water to the main tailings dam one-half mile away, and to skim and retain any oil accidently spilled in the plant site. The system's primary purpose is to prevent tailings spills from reaching the natural drainage.

   Ash blowdown material is directed into the tailings sumps and pumped with the tails to the main impoundment where it settles out with the other solids.

   Periodic inspections are made of the various facilities in the plant site, and strict directives are in force concerning the disposal of waste lubricants, toxic chemicals, boiler washdown water, and any other toxic or deleterious materials that could reach the natural drainage.

4. Water Quality Monitoring - A systematic program of sampling and analysis is in force on all of the effluents from the plant site. Truck-mounted equipment is used for field measurement and sampling, and modern analytical instruments and methods are utilized in both the water treatment laboratory and in the process control laboratory.

   Reports on the various effluents are submitted to the appropriate state agencies where required.

5. Future Abatement Practice - In addition to the removal of phosphate from the sewage effluent, the following projects are current:

   1. Construction of a new tailings impoundment of 2,400 acres just north of the existing structure. The latter will be full in the fall of 1970.

   2. A feasibility study on the use of a polymer type settling agent in place of the lime currently used to clarify tailings water.

6. Conclusion - Insofar as we know, using the best analytical methods and measurement techniques known to us at this time, the White Pine Operation is complying with all state and federal water quality standards for Lake Superior.

E R Bingham

National Audubon Society

NORTH MIDWEST REGIONAL OFFICE
P.O. Box 125 • Atlas, Michigan 48411 • 313-636-2778

May 14, 1969

A statement by Edward M. Brigham, III, Regional Representative, National Audubon Society to the Lake Superior Enforcement Conference, Duluth, Minnesota, May 13-14, 1969.

****

Mr. Chairman, distinguished experts in the field of water quality. I come not as an expert witness on water pollution; but as a concerned citizen representing the National Audubon Society. My region includes the three Lake Superior states.

Water pollution is really a misnomer, it is really people pollution; and since none of us, I dare say, arrived at this conference by horse and carriage, we all are polluters, even though indirectly so. People pollute and people are going to have to un-pollute. This is the reason for this important conference.

It appears that not all are in agreement as to just how much taconite, what level of waste heat, or the precise number of parts per million of DDT constitute a threat to water quality. What happens when knowledgeable people disagree? Dare we accept the counsel of the optimist? What if he is wrong? Must we not decide on that course of action that will preserve the greatest number of options for the future?

An ecologically based decision--one which tends to preserve the natural variability within an ecosystem--is more likely to insure more environmental options than a decision based on economic considerations alone.

Today fish eating birds of prey are in a precarious position because of DDT compounds which interfere with the enzyme/hormone system of these birds. Such interference leads to catastrophically thin egg shells, hence to breakage and reduced hatching success. DDT should have been banned a decade or more ago. Efforts to do so now are being fought by the agri-industrial complex, which has for years cried that proof of damage was lacking or inconclusive. What evidence would they have? What proof would be enough?

It appears from the record that there are technological alternatives which would eliminate or alleviate the major pollution problems being discussed at this conference. The oft heard argument that some alternatives are not economically feasible is indefensible when a continuation of the present course promises ecological detriment. We are beginning to realize that economic wellbeing ultimately depends on the ecological health of the biosphere.

I urge this conference to call for a halt to the dangerous "ecological brinksmanship" that says, "let's wait, there is not enough evidence yet." Our system of law says that a man is innocent until guilt is established beyond reasonable doubt. This same code cannot apply to pollutants and polluters; with these we need to invoke the Napoleonic code: guilty until proven innocent. With Lake Superior there will be no second chance for a millenium.

** A footnote to the matter of eggshell thinness: National Audubon Society's Research Department has recently reported finding the ultimate in thin egg shells in the nest of a bald eagle in northern Michigan: an egg with no shell whatsoever!

Mr. Ralph W. Purdy
Executive Secretary
Michigan Water Resources Commission

May 13, 1969 / [illegible]

Mr Purdy:

Regarding the Conference on Pollution of Lake Superior:

A group of over fifty people in Marquette County, Michigan, located on the south shore of Lake Superior have recently formed an organization called Citizens to Save the Superior Shoreline. As a member of the steering committee of this group I have been asked by vote at a meeting of May 5, 1969, to submit for your consideration the following statement:

> Citizens to Save the Superior Shoreline strongly believe that the long-term benefits of maintaining the high quality and purity of the water of Lake Superior far outweigh any advantages of poorly-planned industrial development. We urge that appropriate Federal action be taken against any industry or agency found guilty of violating the Federal Pollution Control Act.

Respectfully submitted,

Wm. L. Robinson

William L. Robinson
Member, Steering Committee
Citizens to Save the Superior
Shoreline

STATEMENT OF DR. GEORGE G. MALLINSON, DEAN, WESTERN MICHIGAN UNIVERSITY SCHOOL OF GRADUATE STUDIES, KALAMAZOO, MICHIGAN

DR. MALLINSON: Thank you, Mr. Purdy.

I am George G. Mallinson, Dean of the School of Graduate Studies of Western Michigan University, Kalamazoo, Michigan. My home address is 535 Kendall Avenue, Kalamazoo, Michigan, but I am a property owner in Silver Bay, Minnesota.

I am here today in several capacities. One is as President-Elect of the Michigan Academy of Science, which has corporate headquarters in Ann Arbor; President-Elect of the Central States Universities, Inc., which uses the facilities of Argonne National Laboratory, which has corporate headquarters in Argonne, Illinois; the School of Science and Mathematics, which has corporate headquarters in Bloomington, Indiana; also Ohio University; Kent State University; Toledo University; Miami University; Bowling Green State University; Western Michigan University; Ball State University; DePaul University; University of Northern Iowa; Northern Michigan University; Southern Illinois University; University of Detroit; Northern Illinois University.

I want to make it clear for the record that I do not consider myself today an official representative of any of these groups. This was done at my request, since I did not wish to prepare a report or a statement for an endorsement by any of these groups until I had the opportunity to listen to some of the statements that were made by others that were not availed to me prior to my being here.

I have a prepared statement. I request of Mr. Purdy that it be submitted as a matter of record.

Within the next two weeks this statement that I have prepared and that is being submitted will go to the Executive Board of the Michigan Academy, the Board of Directors of the Central States Universities, Inc.; provided it is not privileged, it will appear as the editorial in the School of Science and Mathematics in the forthcoming issue.

Mr. Dominick, may I request whether this may be done?

MR. DOMINICK: Yes, that may be done.

DR. MALLINSON: In deference to the Chairman's request, I will not read the whole statement today, but I will read several comments which I think are relevant.

The first thing I would like to point out is that there is no question whatsoever in terms of scientific definition that Reserve Mining Company, to which this statement is directed, does pollute Lake Superior.

Several years ago when a science advisor from a textile company was working with the United States Public Health Service, which was then involved in water quality, persons in the Sanitary Engineering Center in Cincinnati, Ohio, were developing a series of film strips for water quality and pollution. These are just being published. Pollution represents any intrusion of foreign matter or energy into a natural ecological system.

G. G. Mallinson

In order to determine the validity of this definition, it was submitted to all members of the Cooperative Committee for the American Association for the Advancement of Science. I might say the original definition was changed only in one way, to put the term "natural ecological system." The word "natural" was intorduced. So, in a sense, on the basis of this definition, there is no argument that the intrusion of taconite tailings into Lake Superior is a form of pollution.

As a scientist this will be accepted. I am sure scientists will take that definition. We cannot equate pollution with deleterious effect, these are two different things. Deleterious effect speaks for itself.

The next two points I should like to read are directly in the statement.

Reserve Mining Company admits that only 45 percent of the tailings it dumps in the delta at Silver Bay remain there. Fifty-five percent move from the delta and enter the open waters of Lake Superior. Again, I don't want to debate any more than Dr. Mount what open water means. The only pertinent question is, what happens to the tailings when they leave the delta, and does the migration of the tailings produce deleterious effects. This is getting to the objective heart of the matter.

Dr. Mount's presentation, as well as his collegues, have proved--and I said this as a matter of my own opinion and I am sure that any rational scientific analysis of any of my peers would go along with this--beyond a shadow of a doubt tailings 2 microns and less in diameter do move down the shore and are found in the "green water" phenomenon. Some may choose to argue that this phenomenon is a response to other environmental conditions. Without question, green water does exist without other conditions, but one cannot deny that this green water, that which migrates down the shore with the tracer cummingtonite as the identifier, does contain taconite tailings. The X-ray diffraction studies reported by Dr. Mount have placed an unequivocal brand on the presence of tailings in that green water.

Again, I suppose it is quite possible, and this is a parenthetical statement, to become evasive, quibble and argue, but were these data placed in front of any of the colleagues with whom I have dealt in the last 20 years, there would be no question whatsoever that this is beyond a shadow of a doubt.

Since I have been here I have not heard one shred of evidence presented by anyone--perhaps it may be in reports that may not be available to me--factual evidence to refute the data presented by the laboratory. I haven't heard one shred of evidence. There have only been general statements from which one may infer that the findings just ain't so. We haven't any data which would in any sense on a scientific analysis refute what the laboratory provides us. Here, again, I refer to Dr. Mount's colleagues.

I am quite sure that Reserve Mining Company or any other industry in the United States would give its right arm to have a market analysis which was as extensive and as objective as that.

On Point IV, I will merely make a few statements. The conclusions 4, 7, 8, and 9 on pages 27 and 28 of "An Appraisal of

G. G. Mallinson

Water Pollution in the Lake Superior Basin" certainly clarifies, as everyone knows, that there will be increased absorption of solar energy, the part of the food web in which the fish in Lake Superior survive. I will not expand on this point in deference to our Chairman. Certainly there is evidence in the reduction in the reduction of the abundance of fish food. Again, may I say there is every evidence and every reasonable evidence that there will be an increased solution of metallic compounds including, among others, those of zinc, copper, and chromium, which are toxic to fish.

I was disturbed a little bit about one statement in the report which said--I am bringing this up: In conclusion 10 on Page 28, it is stated that, "the chemical state of these metals was not assessed and it would be presumptuous to say at this time what portion of the elements enter into solution." Again, these are the ones I am referring to that entered the water.

I say quite honestly, without an assessment, this statement is proper and appropriate and defensible. However, it is an established scientific fact that when large masses of material, such as taconite, are reduced to particulate size, their rates of solubility increase exponentially.

I wish to make it clear at this point that the taconite tailings are pure sand, they are inert and are insoluble. This is irrelevant; they are not pure sand. I don't want to go into the details of that here. There is no such thing as insoluble materials; there are those that are relatively insoluble. The question is, does that extent of solubility have a deleterious effect.

G. G. Mallinson

Going to some of the final items now in summary and conclusions, there were two presented, Nos. 9 and 16, which I will read here, and I believe that these are completely confirmed by the evidence that we have.

"The discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, has a deleterious effect on the ecology of a portion of the lake by reducing organisms necessary to support fish life.

"A persistent pollutant entering directly into the waters of Lake Superior or dissolved in the water that feeds the lake mixes with and becomes an integral part of a significant portion of the lake water."

Presented to any rational person, at least those among my peers, these would not be argued. We might nitpick, but arguments are difficult to bring up, at least objective arguments. Certainly, these statements are painfully conservative and noninflammatory. From facts provided earlier and other information from that cited in the bibliography more could be defended. However, one is then faced with the following recommendation on Page 48:

"The FWPCA and the States keep the discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, under continuing surveillance and report to the conferees at 6 month intervals on any findings that interstate pollution is occurring or is likely to occur, and the State of Minnesota is urged to take such regulatory actions as necessary to control the intrastate pollution resulting from these discharges, if

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One is reminded of the recent recommendation of the Federal Power Commission that Consolidated Edison be allowed to build a new power facility in the Storm King Recreational Area on the Hudson River in New York State and afterward carry out a study to determine if the expected thermal pollution produced the predicted ecological damage in the river. This is exactly what the recommendation does to the problem of Silver Bay. I must regretfully say that the Federal Water Pollution Control Administration--Great Lakes Region, had ammunition to kill an elephant in this issue and succeeded only in bagging an anemic squirrel. If this be the limit of the recommendations in the disposal by the Reserve Mining Company, then any discussion about the alleged suppression of the report is academic. There is nothing worth suppressing. Besides, the conferees will meet regularly and have the opportunity to participate in this continuous surveillance. This, again, is a rhetorical question. I do not know to what extent this will be possible.

The facts about the pollution of Lake Superior by Reserve Mining Company have been established. If political considerations are to continue to dictate what happens to Lake Superior, then there is little to do but watch it degenerate, but if integrity is to dictate what happens, there is only one unequivocal recommendation that can emerge, namely, the following:

The U. S. Army Corps of Engineers shall not (and underline that) revalidate the permit to Reserve Mining Company to dispose of taconite tailings into Lake Superior. The Reserve Mining Company shall immediately take steps to develop with the appropriate Federal and State agencies alternate methods of disposal that do not produce deleterious effects, and, within 2 years, shall be using these alternate methods of disposal.

Mr. Chairman, I request that the report be modified to say 3 years. Since this was brought up by Mr. Stoddard, I think in fairness I certainly should go along with it.

If anyone wishes to obfuscate what is obviously desirable action, the means are readily available. Arguments of little substance can be raised about the interstate nature of the pollution. At best they will do little but delay and perhaps prevent what obviously needs to be done.

If a recommendation with substance, such as the one just proposed, does not emerge from the conference, followed immediately by measures for implementation, then all of us present wasted our time by being here.

Thank you. (Applause.)

MR. DOMINICK: Thank you for a very fine and forthright statement. Needless to say, I do not agree with all of your points, but I appreciate the fact you have come forward with such a vigorous statement.

(The statement of Dr. George G. Mallinson in its entirety follows.)

To: Conferees at the Federal-State Conference on Pollution of Lake Superior and its Tributary Basin, held at the Hotel Duluth,

G. G. Mallinson

May 13-15, 1969

Re: Views concerning the pollution of Lake Superior by disposition of taconite tailings in said lake by the E. W. Davis Works, Reserve Mining Company, Silver Bay, Minnesota

By: Dr. George G. Mallinson, Dean, School of Graduate Studies,
Western Michigan University, Kalamazoo, Michigan 49001

Home Addresses:

535 Kendall Avenue
Kalamazoo, Michigan 49007
and
Box 3 A, Star Route
Silver Bay, Minnesota

Gentlemen:

My comments will be directed mainly at the pollution of Lake Superior by the disposition of taconite tailings in said lake by the E. W. Davis Works, Reserve Mining Company, Silver Bay, Minnesota. This should not suggest to any of those attending the Conference that there is no need for concern about other forms of pollution that affect Lake Superior, since they are indeed of great import. However, anyone of sound mind can recognize the colossus of pollution from the Reserve Mining Company, and hence it will be my focus of attention here.

I had assumed, perhaps optimistically, when I accepted the opportunity to "speak for Michigan" at the Conference that a serious attempt was finally afoot to save Lake Superior from the current demise of Lake Erie and the incipient demise of Lake Michigan. I must confess an error of judgment. I have been subjected to what may best be described as a lengthy campaign speech, and a series of emasculated recommendations for future action. I trust the points that follow will clarify my position.

I. Despite the emphasis placed on the fact-finding nature of the Conference by Mr. Klein, Assistant Secretary of the Department of the Interior and by Congressman Blatnik, such viewpoints must be rejected. While I do not wish to raise a semantic issue, facts are not created or found on conference floors. This can only be accomplished by much previous research and staff work. Facts can be revealed, they can be faced, and their relevance can be determined. An attempt to restrict the deliberations to what is referred to as "fact-finding" is a subterfuge for inaction.

II. Reserve Mining Company admits that only 45 percent of the tailings it dumps in the delta at Silver Bay remain there. Fifty-five percent move from the delta and enter the open waters of Lake Superior. Thus, the only pertinent questions at the moment are:

  A. What happens to the tailings once they leave the delta?

  B. Does the migration of the tailings produce deleterious effects?

III. Dr. Mount's presentation, as well as those of his colleagues at the National Water Quality Laboratory in Duluth, Minnesota have proved beyond a shadow of a doubt that tailings 2 microns and less in diameter do move down the shore and are found in the "green water" phenomenon. Some may choose to argue that this phenomenon is a response to other environmental conditions. Without question, green water does result from other conditions, but one cannot deny that this green water does contain taconite tailings. The X-ray diffraction studies reported by Dr. Mount have placed an unequivocal brand on the presence of tailings in that "green water."

Despite Congressman Blatnik's statement, there is no need for new tools and techniques to detect pollution in Lake Superior of the variety described here. All that is needed is implementation of the assertion that "we're going to stop it."

In summary, the westward movement of the tailings into the Duluth-Superior harbor area has been established.

IV. Conclusions 4, 7, 8 and 9 on pages 27 and 28 of An Appraisal of Water Pollution in the Lake Superior Basin are clear evidence of three types of pollution from the presence of tailings in Lake Superior water.

These are:

A. Increased absorption of solar energy needed for the production of phytoplankton that are an integral part of the food web in which fish survive. This fact is part of the typical course in high-school biology.

B. Reduction of the abundance of fish food organisms that live on or just above the lake bottom and which are part of the food web described in IV A above.

C. Increased solution of metallic compounds including, among others, those of zinc, copper and chromium, which are toxic to fish.

In conclusion 10 on page 28 it is stated that, "the chemical state of these metals was not assessed and it would be presumptuous to say at this time what portion of the elements enter into solution." Technically, without such assessment, this statement is defensible. Nevertheless, it is an established fact that when large masses of material are reduced to particulate size, their rates of solubility increase exponentially.

In summary, unless one deliberately seeks to be evasive, there is only one conclusion that can be drawn. The tailings do have a deleterious effect on aquatic life, although the extent of that effect has yet to be determined.

V. On pages 46 and 47 of An Appraisal of Water Pollution in the Lake Superior Basin, there appears these two items under "IV. SUMMARY AND CONCLUSIONS:"

> "9. The discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, has a deleterious effect on the ecology of a portion of the lake by reducing organisms necessary to support fish life."
>
> "16. A persistent pollutant entering directly into the waters of Lake Superior or dissolved in the water that feeds the lake mixes with and becomes an integral part of a significant portion of the lake water."

Certainly the statements are painfully conservative and noninflammatory. From the facts provided earlier and from other information in the reports cited in the bibliography, much broader and incisive conclusions could be defended. However, one is then faced with the following recommendation on page 48:

> "2. The FWPCA and the States keep the discharge of taconite tailings to Lake Superior from the Reserve Mining Company, E. W. Davis Works, under continuing surveillance and report to the conferees at six month intervals on any findings that interstate pollution is occurring or is likely to occur, and the State of Minnesota is urged to take such regulatory actions as necessary to control the intrastate pollution resulting from these discharges, if any."

One is reminded of the recent recommendation of the Federal Power Commission that Consolidated Edison be allowed to build a new power facility in the Storm King Recreational Area on the Hudson River in New York State and afterward carry out a study to determine if the expected thermal pollution produced the predicted ecological damage in the river. I must regretfully say that the Federal Water Pollution Control Administration - Great Lakes Region had ammunition to kill an elephant and succeeded only in bagging an anemic squirrel. If this be the limit of the recommendations with respect to the disposal of taconite tailings in Lake Superior by the Reserve Mining Company, then any discussion about the alleged suppression of the report is academic. There is nothing worth suppressing. Besides, do the conferees represent a standing committee that will meet regularly?

The facts about the pollution of Lake Superior by Reserve Mining Company have been established. If political considerations are to continue to dictate what happens to Lake Superior, then there is little to do but watch it degenerate. If integrity is to dictate what happens, there is only one unequivocal recommendation that can emerge, namely the following:

The U. S. Army Corps of Engineers shall not revalidate the permit to Reserve Mining Company to dispose of taconite tailings into Lake Superior. The Reserve Mining Company shall immediately take steps to develop with the appropriate Federal and State agencies, alternate methods of disposal that do not produce "deleterious effects," and within two years shall be using these alternate methods of disposal.

If anyone wishes to obfuscate what is obviously desirable action, the means are readily available. Arguments of little substance can be raised about the interstate nature of the pollution. At best they will do little but delay, and perhaps prevent what obviously needs to be done.

If a recommendation with substance, such as the one just proposed, does not emerge from the Conference, followed immediately by measures for implementation, then all of us present wasted our time by being here.

In addition, speaking only for the State of Michigan, there is every reason to believe that other mining companies will build facilities on the shores of Lake Superior and the other Great Lakes and will rightfully expect the privilege of dumping taconite tailings into those lakes.

MR. DOMINICK: Mr. Purdy.

MR. PURDY: Mr. Chairman, that completes the presentation on behalf of the State of Michigan.

MR. DOMINICK: Do we have any questions from the conferees at this time for the State of Michigan?

(No response.)

MR. DOMINICK: We will proceed to hear from further Federal witnesses.

I have a letter from the U. S. Department of Agriculture Forest Service signed by George S. James. Mr. James indicated he will have a statement for the record of the conference. If there is no objection, we will receive that statement.

Enter it into the record and be sure the conferees all receive a copy.

(The above-mentioned statement follows.)

MR. DOMINICK: I would like to read into the record a statement that has been provided by the U. S. Department of the Interior, Bureau of Outdoor Recrereation. It reads as follows:

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Eastern Region
633 West Wisconsin Avenue, Milwaukee, Wisconsin 53203

2500
May 8, 1969

Mr. H. W. Poston, Regional Director
Great Lakes Region
Federal Water Pollution Control Administration
33 East Congress Parkway, Room 410
Chicago, Illinois 60605

Dear Mr. Poston:

Attached is a statement with respect to the conference in the matter of pollution of Lake Superior and its tributary basin to be held in Duluth, Minnesota, on May 13 as promised in our letter to you of April 28.

As indicated in our April 28 letter we are not asking for time to present this statement at the conference. We request, however, that this statement be included in the records of the conference.

Sincerely,

GEORGE S. JAMES
Regional Forester

Enclosure

STATEMENT BY GEORGE S. JAMES, REGIONAL FORESTER EASTERN REGION, U. S. FOREST SERVICE, MILWAUKEE, WISCONSIN

(For inclusion in the records of the conference in the Matter of Pollution of Lake Superior and its Tributary Basin at Duluth, Minnesota, May 13, 1969.)

The Eastern Region of the U. S. Forest Service consists of 17 National Forests located in a 20-state area, spreading from Minnesota to Missouri to the northeastern states. There are four National Forests located in the Lake Superior watershed.

The Hiawatha National Forest, consisting of two separate units located in upper Michigan, has approximately 15 miles of shoreline in Federal ownership. Most of the streams draining into Lake Superior are quite short. The Au Train River in the west unit is the only stream of any length. Most of the soils in the Lake Superior watershed are quite sandy. The forested watersheds yield a relatively stable flow. Water quality is generally quite good.

The Ottawa National Forest, located in western upper Michigan, lies largely within the Lake Superior drainage. Major rivers with headwaters in the National Forest are the Ontonagon, Presque Isle, and Iron Rivers. The soils on the Forest are quite varied ranging from sands through clay to rock. Streamflow regimen reflects this diversity in soils. Furthermore, some water quality problems are evident. The Ontonagon River carries quite a large suspended sediment load as a result of large amounts of eroding clay banks. You are aware, of course, of the effect of this sediment upon anadromous fisheries. We are implementing corrective measures on National Forest lands as monies permit. Other streams have sediment problems to a lesser degree.

Minor water quality problems are created as a result of the inflow of sanitary systems to the streams of the Forest. Many of these systems need to be updated. Nutrient input to streams is common.

In the western part of the Forest many of the streams carry large amounts of dissolved organic materials from the large areas of swamp. These dissolved organics impart a dark color to the water and cause foaming at the many rapids and falls along the stream length. This condition is not desirable from esthetic point of view.

The Chequamegon National Forest is located in northern Wisconsin. That portion of the Forest lying within the Lake Superior watershed is largely clay. Streamflow regimen tends to somewhat flashy. Flooding results from heavy rains and spring thaws. The headwaters of the White and Bad Rivers lie within the National Forest. These streams contain large suspended sediment loads. However, most of this sediment is derived downstream from National Forest lands. Other water quality problems with the National Forest are minor.

The Superior National Forest is the only National Forest situated on the north shore of Lake Superior. The streams are short and of steep gradient. The soils range from clays to bedrock. Streamflow regimen is fairly stable. Water quality is quite good except for some inland lakes which have been subject to nutrient inputs and have aquatic nuisance conditions periodically. Major streams are the St. Louis, Poplar, Pigeon, Brule, Temperance, and Cascade Rivers.

The dumping of taconite tailings into Lake Superior must be evaluated.

Any corrective action that is necessary should be taken. We are most anxious to analyze the possible impact of this procedure on our recreational developments and programs.

The Organic Act of June 4, 1897, cites "securing favorable conditions of water flows" as a principal purpose of National Forests. The Weeks Act of March 1, 1911, further recommends for purchase such forested, cutover, or depleted lands within the watersheds of navigable streams, as may be necessary to the regulation of the flow of navigable streams.

Because those "favorable conditions of water flows" and "the regulation for the flow of navigable streams" include quantity and timing, in addition to quality, a great responsibility lies with the Forest Service in the use, management, and administration of these key lands.

To meet Forest Service responsibilities in the water resource field, there are established water resource objectives for all watersheds. These objectives are determined by examining the total water resource use and the related needs both within National Forest boundaries and for areas downstream, and both for National Forest and non-National Forest purposes.

We consider all water uses including municipal, commercial and industrial, agricultural, recreational (including esthetics), fish, and other aquatic life, wildlife, and forest activities, both present and future.

Based on water needs, if the conditions of water flows are satisfactory regarding the quality, quantity, and timing of flows, then water resource objectives include protection requirements to insure that the present satisfactory conditions are maintained. Other resource activities, such as recreation use, timber harvesting, and road building must be carried out in a manner which will prevent stream sedimentation and other pollution. Timber harvesting contracts contain clauses directed towards the prevention of stream sedimentation and other pollution. We believe that managed timber harvesting causes little, if any, sedimentation or other pollution.

Other water quality protection requirements include the proper design of Forest Service sanitary systems to insure that the affected natural waters meet the standards set for the various uses of that water. Forest Service sanitary engineers, watershed scientists, soil scientists, and geologists are all involved to insure adequate design of sanitary systems. The Federal Water Pollution Control Administration further approves our sanitary system designs.

Of primary concern is the problem of excessive fertilization of surface waters This problem is of more immediate concern to smaller inland lakes within the Lake Superior basin. Eutrophication of surface waters is accelerated by excessive use of fertilizers and the dumping of nutrients from sanitary systems into the waters. Various systems of sewage treatment may be safe from a health standpoint and yet be responsible for the addition of phosphates, nitrates, and other nutrients to surface waters to the point where the waters become esthetically unpleasing with algae blooms and other weed growth. In extreme cases, the biotic balance and fisheries of the waters may be harmed. Developments with septic systems in very permeable soils as well as impermeable soils ringing small lakes can be responsible for accelerated eutrophication.

If there is a need to improve the quality, quantity or timing of the water resource appropriate improvement objectives are established. We may employ any reasonable action to meet these objectives. These land management prescriptions may include such things as the restoration of the eroding streambanks, the effective use of vegetation or engineering structures to regulate the quantity and timing of waterflows, or the proper redesign of faulty sanitary systems.

While the water resource is the prime factor in any land management decision, other resource uses of these lands are, and must be, made. Land management prescriptions to meet water resource objectives must be in harmony with these other resource uses. This is in accordance with the multiple use principle set forth in the Multiple Use Sustained Yield Act of 1960. Multiple use is the management of all the lands so that the renewable surface resources of the National Forests are utilized in the combination that will best meet the needs of the American people.

In accepting our responsibilities, we have developed five Forest Service policies related to water quality:

1. Insure that return flows, particularly those associated with recreation and other domestic use, do not impair natural waters for the other purposes water is expected to serve.

2. Make certain that National Forest land management practices are conducted in a manner which will insure a quality of water yield suitable for its intended purposes.

3. Maintain a water quality satisfactory for other National Forest resources uses, such as fish habitat, and swimming and related uses whenever it is within the capability of the Forest Service to do so. All Forest Service swimming areas are now monitored to insure that they are safe for swimming.

4. Insure biologically safe, suitable drinking water for use of the public. All wells are monitored and tested on a planned basis.

5. Modernize sanitary systems at existing Forest Service installations where necessary. An approved sanitary system at all new installations is a basic part of the installation plan.

Compliance with these guidelines is no simple task. A large portion of the gross area within National Forest boundaries in the Lake Superior watershed is held in private ownership. We have no jurisdiction over these private lands. A large proportion of this private land is located along major streams or adjacent to lakes, constituting a potential pollution source over which the Forest Service has no control.

The most obvious way, then, to make a meaningful contribution to the water quality problem starts with cooperation with private landowners, industry, and the various Federal, State, and local Government units.

One of our objectives is to cooperate with the various states in improving fisheries habitat. We are becoming increasingly involved in the anadromous fisheries program in the Great Lakes. Good quality waters are needed for salmon and trout fisheries. Water temperatures must be maintained within acceptable limits. Chemical pollutants must be held below certain limits. Siltation must also be maintained below certain acceptable limits to prevent the filling of spawning beds with sediments and the accompanying reduction of oxygen levels. Often what we do to control erosion on National Forest lands is negated by the erosion that is still taking place on other lands upstream.

Thus, we are not only concerned with the effect of our management on water quality. We are also concerned with the effect of the quality of waters beyond our control on our ability to provide needed services for the American people. For instance, we now have recreation areas with swimming facilities along Lake Superior shores. We are planning additional recreational facilities of this type. The water quality of Lake Superior will, in part, determine the enjoyment that the people will derive from these areas and the economic development of the surrounding area associated with these recreational facilities.

Compared to the total impact of man on water quality in Lake Superior and its tributary waters, the National Forests influence water quality to a relatively small degree. Nevertheless, the Forest Service can and does contribute to the water quality of the Lake Superior watershed. It is our sincere desire that our contributions to this very important aspect of our total environment are meaningful and correct. We will make every effort to insure that they are.

Bureau of Outdoor Recreation

BUREAU OF OUTDOOR RECREATION, U. S.
DEPARTMENT OF THE INTERIOR,
WASHINGTON, D. C.

During the last decade, the people of this country have become increasingly conscious of the current and potential values of outdoor recreation, and much of this interest has been centered around the use and enjoyment of our water resources. All indications point toward a future need to provide not only more but also a wider variety of outdoor recreation opportunities.

Recent trends indicate a rapidly increasing interest and participation in water-based recreation activities, especially the water-dependent activities of swimming, boating, water-skiing, and skin diving. There is also a growing interest in nature photography and study, often involving the aquatic environment.

The availability of more leisure time and increased use of leisure time for outdoor recreational activities will place greater demand on our lakes and streams. The increase in leisure time associated with a general higher disposable income will provide the people in the Lake Superior Basin, as well as nonresident vacationists, an opportunity to participate in outdoor recreation more frequently and for longer periods of time. The number of occasions in which people will engage in water-oriented outdoor recreation activities in the Nation will increase about 160 percent during the next 40 years, according to the latest Bureau of Outdoor Recreation estimates.

Bureau of Outdoor Recreation

The economics of outdoor recreation cannot be ignored. Michigan and Wisconsin have both reported their tourist industry as being in excess of $1 billion a year. Minnesota indicates that tourism is the third largest industry in that State. The basin itself contains about 190 Federal, State, and local recreation areas, including such outstanding areas as Isle Royale National Park, the Pictured Rocks National Lakeshore, Michigan's scenic copper country, Tahquamenon Falls State Park, Porcupine Mountains State Park, and Minnesota's Scenic North Shore. The development of these facilities, along with the supporting facilities such as motels, gasoline stations, and sporting goods manufacturing and sales, represents a considerable private investment in the basin. The Bureau is or will participate in several water resource studies involving all or portions of the Lake Superior Basin, including the International Joint Commission Great Lakes Water Levels study, Great Lakes-Illinois River Basins Projects studies, Great Lakes Basin study, and estuarine studies.

The Lake Superior Basin is an area of outstanding natural resources and great recreation potential. The basin contains more than 3 million acres in public forest, parks, and wildlife areas with only 0.2 percent of this developed for outdoor recreation purposes. At present, however, only moderate demands are being placed on the basin's recreation resources. The current annual recreation demand is estimated about 16 million recreation days, and, by the year 2000, this is expected to double. In 1964, it was estimated that 1.4 million vacationists came to the Lake Superior Basin for outdoor recreation. Vacationists account for

80 percent of the total basin recreation.

The majority of recreation activities in the basin are centered around or near water. These include such water-dependent activities as boating and fishing, and water-enhanced activities such as hiking, camping, and sightseeing. Although it is recognized that recreationists participate in all the other basic activities in addition to sightseeing, it is the attraction of this latter activity which draws most recreationists to the basin.

Probably Lake Superior's greatest asset is its scenic shoreline. Obviously any factor which tends to endanger or reduce the amount or number of clean water areas and aesthetically attractive streams, lakes, or shore areas suitable for recreation purposes should be of great concern to everyone involved in managing our natural resources for public benefit.

Water serves three basic needs of recreationists: consumptive, that is, drinking and cooking supplies; surface and volume for water contact activities, fishing and boating; and for aesthetic enjoyment. Water areas also are vital to the preservation of fish and wildlife, unique biotic communities and, in combination with adjacent lands, the highly valued scenic natural character of certain areas.

The Bureau of Outdoor Recreation is interested in seeing quality recreational opportunities provided. Polluted water is not compatible with this goal. It is not only undesirable for boating, waterskiing, and swimming, but is unattractive for camping, picniking, and may be a health hazard in connection with these and other water-contact uses. The polluting of recreational waters results in decreased use and can render areas totally unsuitable for such use. Although progress in the abatement of pollution is considerable, large amounts of pollutants still are being discharged into our water courses.

The Bureau is vitally concerned about the maintenance of the best possible water quality in Lake Superior, and has particular concern for the quality of waters in the vicinity of Duluth Minnesota, and Superior, Wisconsin, Chequamegon Bay near Ashland, Wisconsin, and those waters in the vicinity of Silver Bay, Minnesota.

Surveys have revealed that the Lake Superior Basin is endowed with a wide variety of recreational, scenic, historical, and natural values. Many of these values depend upon the quality of water available.

Water-oriented outdoor recreation may be divided into two categories--water-dependent and water-enhanced. The former category includes swimming, waterskiing, boating, and fishing. The water-enhanced category includes activities including the aesthetic enjoyment of viewing water such as camping, picnicking, and sightseeing. Water quality degradation not only threatens to eliminate or seriously limit existing developments, but it also precludes future or expanded developments at many desirable sites.

Bureau of Outdoor Recreation

Closely allied with water quality are other environmental problems which set the tone of livability, particularly in urban areas. In many cases the solution of these problems is interrelated with water quality. Social values are assuming greater importance in resource allocation and development and cannot be modeled to fit a clean-cut cost-to-benfit analysis. The social revolution now in progress demands new thinking and new methods of solving problems. The high cost of solving water and air pollution as an initial step to improving livability may be minor when compared to the social and sometimes irreparable damage of pollution. Recreation opportunities will be increased substantially by a coordinated multi-state pollution abatement program, but the greatest beneficiaries to the program will be the people who live near and use the lake. (Mr. Dominick continuing.)

The following Federal agencies have submitted statements for the record:

The Great Lakes Basin Commission.

Will you distribute those statements at this time?

STATEMENT OF MR. VERNE M. BATHURST, ALTERNATE CHAIRMAN, GREAT LAKES BASIN COMMISSION

(The statement of Mr. Bathurst follows.)

STATEMENT BY MR. VERNE M. BATHURST, ALTERNATE CHAIRMAN, GREAT LAKES BASIN COMMISSION, ANN ARBOR, MICHIGAN, AT THE CONFERENCE IN THE MATTER OF POLLUTION OF THE INTERSTATE WATERS OF LAKE SUPERIOR AND ITS TRIBUTARY BASIN (MINNESOTA-WISCONSIN-MICHIGAN)

May 13, 1969
Duluth, Minnesota

While I am the Alternate Chairman of the Great Lakes Basin Commission, I will be speaking from the standpoint of the Commission as a whole and not necessarily representing the views of any individual Commission member. Each of the States in the entire Great Lakes Basin (including Minnesota-Wisconsin-Michigan),as well as every Federal Department having a role in the water and related land resources of the basin, are members of the Commission.

As a Commission, we are vitally interested in the water quality aspects of Lake Superior. At the present time, we are sponsoring the on-going Great Lakes Basin Framework Study which is to be concluded in 1972. Lake Superior is an integral part of this Framework Study. This study, a preliminary-type investigation, will (1) provide broad-scaled analyses of water and related land resourcesneeds and problems, and (2) furnish estimates of the probable nature, extent and timing of measures for their solution.

The Great Lakes Basin Commission was established by Executive Order on April 20, 1967 and in accord with the Water Resources Planning Act of 1965. The principal duties and responsibilities of the Great Lakes Basin Commission, as stated in the Act, are:

> The Commission shall, to the extent consistent with Section 3 of the Act--
>
> (1) serve as the principal agency for the coordination of Federal, State, interstate, local, and nongovernmental plans for the development of water and related land resources in its area, river basin, or group of river basins;
>
> (2) prepare and keep up-to-date, to the extent practicable, a comprehensive, coordinated, joint plan for Federal, State, interstate, local and nongovernmental development of water

> and related resources: Provided, that the plan shall include an evaluation of all reasonable alternative means of achieving optimum development of water and related land resources of the basin or basins; and it may be prepared in stages, including recommendations with respect to individual projects;
>
> (3) recommend long-range schedules of priorities for the collection and analysis of basic data and for investigation, planning, and construction of projects; and
>
> (4) foster and undertake such studies of water and related land resources problems in its area, river basin, or group of river basins as are necessary in the preparation of the plan described in clause (2) above.
>
> The river basin commission shall--engage in such activities and make such studies and investigations as are necessary and desirable in carrying out the policy set forth in Section 2 of the Act and in accomplishing the purposes set forth in Section 201(b) of the Act.

We're here in conference in the matter of pollution because Lake Superior is the victim of the people's success, not failure. Our population and industrial growth have exploded. Increased leisure time and people intent on using some of their time enjoying the Lake have put undreamed recreational demands on Lake Superior.

Many of you with direct and official concern with water-quality conditions have been alert to the problems caused by this success. And because of such concern, our legislatures have worked overtime to change our laws to meet these new conditions and problems. You know that these laws have been required by problems growing each year in geometric proportions. This conference can help us decide how we can best use these laws, not only to keep our water problems from getting worse, but to make some headway in solving them.

As I see Lake Superior, and the entire Great Lakes Basin for that matter, our activities concerning the Lake have been fragmented. But this is because the problems appeared to be fragmented and our responses to them were fragmented. Lake Superior and the other lakes are really a vast sea. As pockets of population settled along the shores, communities could act independently. So as long as you could take your drinking water upstream, empty your wastes downstream, have your beaches far enough away from your water intakes and wastes, and have your dishes and clothes washed in old-fashioned soap, you had little concern for problems.

As our separate problems began running into other problems, we created problem-solvers. The Great Lakes Basin Commission is now in the process of preparing a report on "Great Lakes Institutions" which indicates that there are over sixty-two (62) State, Federal and international agencies active in water-related activities in the Great Lakes. In addition, many universities, local government and nongovernmental entities are also very active in various aspects in evaluating problems and finding solutions.

Almost all of these agencies are overworked, understaffed, and just beginning to get public recognition of the losses because of insufficient action, as well as acceptance of the dollar-cost of action. Indeed, as we add staff and increase the number of agencies, we find that, with the population growth, we've gotten even further behind. And, as the problems become critical in more places and more places spend money, they each find themselves in agonizing competition for money, materials, and men.

Finally, we're finding, as usual, that some of our solutions become bigger problems than the one resolved. Not only are the solutions in conflict, but the agencies given problems to solve, find themselves in conflict with other agencies trying to carry out their own problem-solving mission.

Well, one could go on, but you know all of this. Suffice it to say that, in a very complex society, we've come to recognize that what happens in Lake Superior affects what happens in the other Great Lakes; that the solution to one problem has to be related to the solution for other problems; and that what one unit of government does within its claim of sovereign right must be related to what another unit of government does under its claim of right. In other words, we have come to recognize that there must be both coordination and comprehension.

Congress recognized these concepts when it enacted the Federal Water Pollution Control Act under which this conference is being held. But it has gone further and recognized that the coordinated and comprehensive action to solve pollution problems must also be related to coordinated and comprehensive programs in every other aspect of the water resource. And hence the Water Resources Planning Act was passed in 1965.

The Framework Study now underway and the development of the more detailed Comprehensive Coordinated Joint Plan will provide the means for developing the coordinated, comprehensive, joint action programs in the matter of water quality as well as all other aspects related to the water resources of Lake Superior. The Work Groups organized for the development of the Framework Study represent State, Federal and local governmental units as well as some private firms with the Great Lakes Basin Commission as the principal coordinating agency. These Work Groups are now assembling data on the Great Lakes Basin and making preliminary evaluations. As results are being developed, these will be coordinated with any plans being developed by any governmental units or private areas for the conservation and utilization of the water and related land resources of the Great Lakes Basin.

In conclusion, let me state that the pollution control programs have to be coordinated at all levels of government, industry and private aspects to achieve both the immediate and long-range objectives to an optimum water quality program. What I said relates primarily to better and more coordinated institutional arrangements for fighting our water quality problems. We need to recognize that at some point we have to find ways of making choices between alternative uses of our water resources, including the enhancement of the water quality environment. The function of the planning efforts is to make these choices with knowledge and wisdom, not alone with emotion. We must not bring preconceived opinions into the planning process without thoroughly testing such opinions against existing conditions and attitudes.

U. S. Department of Agriculture
and Soil Conservation Service

MR. DOMINICK: We have the statement of the United States Department of Agriculture and Soil Conservation Service.

(The above-mentioned statement of the U. S. Department of Agriculture and Soil Conservation Service follows.)

STATEMENT ON SEDIMENT POLLUTION
LAKE SUPERIOR AND ITS TRIBUTARY BASINS

All of us are concerned about our growing population; the future need for space; the wise and effective us of land and water resources and, most of all, having a healthy and pleasant place to live and work.

Despite the progress we have made to conserve and improve our natural resources, we still find our land being misused, erosion occurring, and our streams being polluted. Serious sediment pollution is occurring in the Lake Superior Basin.

Throughout the Basin, topography and soil development has been influenced by glacial action. As the glaciers advanced and retreated, they sorted, sifted, moved, and removed the soil parent materials; leaving behind a great variety of soils and site conditions with many varied and complex problems. Almost all of the glaciated soils have management problems.

Our environment is deteriorating from pollution in the form of dirty water, foul air, and contaminated soil. Sediment from runoff is a despoiler and a major threat to clean water. Runoff causes excessive erosion on mismanaged cropland, grassland, forest land, urban and recreation areas; or any area where the vegetation is disturbed, sparse, or is lacking. Unprotected land results in a scarred landscape with gullies and with a reduced productivity.

Runoff causes not only soil particles, but also other pollutants, such as sewage, infectious agents, plant nutrients, organic chemicals, salts, mineral substances, and insecticides to be deposited in our lakes, creeks, small streams, and rivers. Four million tons of soil material are translocated in the United States each year by flowing water. About one-fourth of this sediment, or 100 million tons, reaches the major water bodies annually. Although Lake Superior is not being contaminated as rapidly as the other Great Lakes, the threat exists. Because of the nature of this lake, it would take an untold number of years to purify itself. Prevention, therefore, is the only route we can pursue.

The major sources of sediment in the Superior Basin are sheet erosion by water; gullying by runoff; streambank erosion; flood erosion by scouring low areas; erosion from urban, industrial, and other construction sites; roadside erosion from cuts and fills; runoff from surface mined areas; and pollutants from wastes of cities and industries.

Statement by Verne M. Bathurst, State Conservationist, U. S. Soil Conservation Service, East Lansing, Michigan, for the Lake Superior Pollution Conference, Duluth, Minnesota, May 13, 1969.

A smaller portion of the land in the Lake Superior Basin is in farms than in other parts of the United States. Cropland, therefore, does not contribute as much to the total problem as it does in other more extensively farmed areas. Land being tilled produces the most soil loss per acre when it is in row crops. There is a relatively small acreage of cropland devoted to row crops in the Basin. The amount of sediment production is dependent on the kinds of crops, tillage practices, slope, and climate.

While some agricultural and forest land produce significant amounts of sediment, urban areas under construction may produce even more per acre. Since many of these areas may be close to streams a large amount of sediment is introduced directly into the water. Cultivated agricultural lands are widely scattered in this drainage area, and much sediment is filtered out before it reaches a major water source.

Forest and grass lands generally contribute less sediment per acre, but when disturbed and denuded of vegetation, these areas are difficult to heal. When the Lake Superior Basin was first settled, forests were cleared, and bare soil exposed, serious erosion resulted. Fires eliminated natural vegetation. These conditions were aggravated through destructive logging practices, improper construction, and inadequate maintenance of roads. Grazing along streams and steep slopes exposed erosive soil with only average rainfall intensity. As a result, many denuded and mismanaged forest and grass lands are still contributing to the pollution problem.

Highway and road construction has been a major source of sediment production. Improvements have been made in controlling sediment, but considerably more is urgently needed, particularly along county roads. Most of the erosion comes from new or recent road grading or shaping. These areas, because of soil and slope, may take years to stabilize under natural conditions.

Another source of sediment pollution is the land disturbed by surface mining. These areas may erode enough to form rills and gullies, causing a heavy sediment load that may drain into streams and lakes, destroying fish and natural beauty. Sand and gravel pits also pose an erosion problem, although not as extensive. It is difficult to establish vegetative cover on these areas. The uncovered soil materials are exposed to wind and water erosion and their sediment is easily added to adjacent streams.

Much of the sediment in many streams comes from erosion from the streambank itself. This problem is widespread, particularly along the larger streams. Some of this is due to soil conditions which are difficult to stabilize. Significant amounts of the erosion is due to lack of cover. The cover is removed by construction, animal grazing, or even excessive human use in popular fishing and recreation sites. Because streams and river banks are part of the water and sediment conveyance system, soil eroded is immediately converted to damaging sediment.

This is also true of erosion on lake shores where tons of soil are deposited directly into lakes each year. In some areas, sand dunes cause a problem. They are usually bare of vegetation and are continually shifting and moving, covering roads, woodlands, and filling waterways.

Land use changes, since the early days of settlement in the Basin, have accelerated the runoff. Hundreds of acres of highways and developed areas cover the soil surface with impervious layers of concrete and blacktop which prevent the precipitation from entering the soil. This increases the volume and rate of runoff. The result is peak flows that exceed channel capacities resulting in extensive flood damage. Excessive runoff causes floodplain scouring which adds to sediment pollution. Water shortages may arise where flooding and sedimentation have made local supplies unuseable.

The detrimental effects of soil erosion and sediment are infinite. Sedimentation reduces storage capacity and makes water unfit for certain uses. Sediment materials which are eroded and transported by water are later deposited as sediment and cause downstream damages to waterways and fish and wildlife habitat.

Each year this deposition in channels, in reservoirs, and in harbors adds up to tremendous losses in both water quantity and water quality. Sediment obstructs storm sewers and road ditches. It impedes navigation in harbors and waterways and makes municipal and industrial water treatment expensive. In some situations, sediment has clogged underground acuifers and reduced the effectiveness of recharge areas.

The many salts and nutrients adsorbed on sediment particles lower the water quality and speed the eutrophication of lakes. As an example, phosphates applied as fertilizers have a great affinity for soil particles and are usually moved into streams only as soil moves. Keeping soil in place reduces phosphate pollution.

The deposition of sediment on beaches detracts from their recreational use and affects the aesthetic value as well. It also has a detrimental influence on the recreation value of water for swimming, boating, skiing, and fishing.

The red clay soils of northwestern Wisconsin are particularly receptive to erosion. The area contains 800,000 acres of unstable soils. An interagency committee has indicated that sediment in streams and rivers is the number one problem from this highly erodible area. There have been catastrophic floods with accelerated erosion. Even minor precipitation is accompanied by a great deal of soil loss. These kinds of soils also exist in other areas within the Superior watershed.

In the past, erosion control on farms has received the most attention. Conservation measures must be applied to all other land uses if the sediment problem is to be reduced. The unwise use of any land fills reservoirs with sediment, floods basements, pollutes water, damages roads, and affects wildlife and recreation areas. With the further concentration of industry and people in the Lake Superior watershed, the problems of sediment pollution will be intensified. All segments of society must lend their support to effective sediment control programs. Soil surveys which identify the location and extent of erosive soils are a necessary part of a sediment pollution control program.

I have mentioned many of the sediment problems and how they are affecting our environment. Effective solutions to these problems have been developed.

A majority of the acres used for cropland need conservation treatment of some kind. Erosion hazards are the dominant problem on agricultural land.

In general, the cropland in the Lake Superior Basin area would benefit by stripcropping, contouring, terracing, and complementary cover and proper rotations. The application of these measures would reduce runoff and erosion significantly.

Pasture and grass lands need conservation treatment and improvement. Establishment of cover on steep, erosive slopes and improving existing cover on denuded areas are first courses of action. Water management and protection from overgrazing are other types of treatment needed.

More than half of the acres of private forest and woodlands likewise need treatment. These lands would benefit from protection from fire, insects, disease, and animals. Tree planting and management would aid erosion control.

Erosion and resultant sedimentation can be greatly reduced by proper soil and water conservation practices on the many miles of road cuts and fills in the wooded areas. This can be done by proper seeding and mulching of exposed soil areas.

Gullying, streambed and streambank erosion can be controlled by use of measures, such as check dams, drop structures, streambank protection work, or gradient control structures. In addition, floodwater retarding structures, stream regulating reservoirs, and debris basins are needed for detention of sediment that would otherwise reach downstream water courses and harbors.

The cost of roadside erosion control varies. It may run from $200 a mile to many times that amount for complete control with proper sloping, vegetation, drainage, and structures. Road builders, developers and other land users can reduce erosion and subsequent deposition by:

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(1) exposing the smallest amount of bare soil for the shortest period of time

(2) using temporary ground cover and planting permanent sod quickly

(3) using diversions, sediment basins, and terraces to trap sediment that does erode away

(4) retaining and using natural vegetation whenever possible

(5) conforming to natural topography and land drainage where possible.

The mining industry, soil conservation districts, and all levels of government need to work together to apply practical conservation principles in reducing sediment pollution from surface mining. Before mining begins, a plan should be worked out to prevent the heavy sediment loads from moving into water courses. While mining is going on, steps need to be taken to control erosion on the site and on haul roads. Quick-growing plants for immediate protection and permanent cover are needed when mining is finished. Surface runoff in mining areas must be controlled on a watershed basis to fit stream capacities and prevent harmful deposition. Drainage must be controlled to keep sediment out of streams. Lakes and sediment ponds can be created on the excavated sites. The proper use of vegetation and water management would control sediment, add beauty, and permit wildlife habitat development in the area.

The quantity and quality of water that reaches the streams and lakes are determined by land use and treatment upstream. The U. S. Soil Conservation Services now have the technical capabilities to deal with the problem. It is, however, limited by legislative authorities and financial resources.

Local governments need further assistance to develop effective erosion and sediment control programs in urban and industrial areas. This additional financial and technical assistance could aid in the formulation of land use and sediment control regulations.

Added emphasis on the control of erosion along highways, streambanks, lakes, and strip-mined areas is necessary. Controlling sediment has long been an essential part of U. S. Department of Agriculture and Soil Conservation Service.U. S. Department of Agriculture offers a wide variety of technical assistance, cost-sharing, research and credit assistance. Its conservation programs serve all land users.

A large part of these services consist of helping individuals, communities, groups, organizations, and/or other Federal and state agencies preserve and maintain the soil and water resources.

This directly relates to the reduction of sediment pollution of our streams, lakes, ponds, and reservoirs. Uncontrolled sediment may affect every citizen with higher taxes, higher electricity and water bills, plus higher food and clothing prices. It is better to practice conservation and hold the soil in place for a few cents a cubic yard rather than pay in dollars a cubic yard to remove sediment from roads, harbors, rivers, and reservoirs.

Much has been done to correct erosion problems. The U. S. Department of Agriculture's Soil Conservation Service is the technical arm of action with responsibility for soil and water conservation. It provides the assistance of professional conservationists to all land users and land use decision makers. These include planning commissions, land use boards, health officials, county governments, and others by providing soils information and technical assistance. This assistance is generally given through soil conservation districts who promote conservation programs for all land users. Soil Conservation Service technical assistance is provided in the application of conservation measures for erosion and water control. This includes measures for retarding water flow and reduction of sediment damage in streams and lakes and along highways.

The Soil Conservation Service gives technical and financial aid to local organizations under the Watershed Protection and Flood Prevention Act in planning and carrying out watershed projects. The purpose of these watershed projects is flood prevention, watershed protection, agricultural water management, recreation, municipal and industrial water supply, and fish and wildlife development. These are small, community-size projects.

The Soil Conservation Service, through the watershed program, pays the cost of engineering services and contruction costs for flood prevention and up to 50 percent of the construction costs for irrigation, drainage, recreation, fishing, and wildlife developments. All other costs are paid by local organizations.

The Soil Conservation Service has leadership responsibilities in Resource Conservation and Development Projects. These projects stimulate growth through acceleration of conservation activities and land use adjustments. Federal participation includes technical assistance to help landowners install conservation measures, cost-sharing assistance on certain approved conservation and development measures, and credit to help landowners and local sponsors finance improvements of the soil and water resources. Most U. S. Department of Agriculture agencies may become involved in this total resource development effort which will affect the sediment and deposition in streams and lakes over a multicounty area. There are five Resource Conservation and Development Projects in Minnesota, Michigan, and Wisconsin.

The Soil Conservation Service has U. S. Department of Agriculture leadership in river basin planning activities. This program defines problems related to water and related land resources for which project type solutions are necessary. Funds and legislation are needed to carry out the necessary conservation measures. Cost-sharing, credit and research are provided by the Agricultural Stabilization and Conservation Service, the Farmers Home Administration, and the Agricultural Research Service. The Forest Service carries out erosion control measures on Forest Service land.

Conservation today encompasses the full sweep of all natural resources, their development, preservation, and use. A narrow, piecemeal approach toward conservation dealing with one resource, or one use, or one purpose will not provide lasting benefits. There must be planning for management and coordination of uses. These uses must blend harmoniously with our natural environment if man is to survive.

The services available from the U. S. Department of Agriculture agencies constitute the most important part of a sediment control program. Only through such programs can sediment pollution in Lake Superior be effectively reduced. We welcome the opportunity to join with you in your efforts to maintain and improve the quality of Lake Superior water. We stand ready to do all within our resources to help in this important program. History will prove that our combined efforts to reduce pollution in Lake Superior are honorable.

B. J. Miller

MR. DOMINICK: We also have the statement from the U. S. Department of Interior, National Park Service.

(The above-mentioned statement follows.)

STATEMENT OF NATIONAL PARK SERVICE PARTICIPATION IN POLLUTION ABATEMENT ON LAKE SUPERIOR

To Conferees, Lake Superior Water Pollution Conference,
Duluth, Minnesota, May 13, 1969
From Bruce J. Miller, Assistant to the Regional Director,
Great Lakes Area Office, National Park Service

"I regret not being able to present this statement personally to your gathering, and since the subject of pollution to Lake Superior is of extreme concern to the National Park Service, I am taking this method of explaining our stand on this important subject.

"The National Park Service has four operational units bordering on Lake Superior, they are:

Grand Portage National Monument, Minnesota
Isle Royale National Park, Michigan
The Houghton Headquarters for Isle Royale, Michigan
Pictured Rocks National Lakeshore, Michigan

B. J. Miller

"Of greatest concern to us in the past was the operation of the MV Ranger III, a 125 passenger vessel, transporting cargo and passengers between Houghton, Michigan and Isle Royale. Due to lack of land facilities, it was necessary to empty the holding tanks midway between the island and the mainland. This past year, the village of Houghton was successful in obtaining the necessary permit to install connecting sewers under a railroad right-of-way, and make it possible for us to tie in to the village system. We are now able to empty our holding tank into a built-in manhole on our Houghton dock. Thus, there will be no more waste pollution into Lake Superior from the operation of our vessel.

"At Isle Royale National Park, we have been engaged in a program endeavoring to educate the private cruiser operator in anti-pollution practices. Each boat that registers at the island, and we have nearly 100 percent registration each summer, is issued a card--sample attached--informing the operator of our regulations. Additionally, last summer the National Park Service constructed a trailer mounted tank with pump capable of pumping out holding tanks of cruisers. This unit will be in full operation this summer. The trailer tank is emptied into the Mott Island septic tank, rather than into the Lake. We believe this unit will receive heavy use. At least two more of these units are scheduled to be built; one for the Windigo dock in Washington Harbor, and one for the Rock Harbor dock.

"All heads on National Park Service boats have been sealed, or made inoperative at Isle Royale.

"The Superintendent of Pictured Rocks reports that all developments being planned for the National Lakeshore will call for disposal lagoons located in such fashion as to preclude any run off into watersheds leading into Lake Superior. He is personally reviewing each master plan drawing to determine that every possible precaution is being taken to avoid pollution of Lake Superior.

"The Superintendent of Grand Portage reports that sewage disposal at present, is by use of septic tanks. He added that the U. S. Public Health Service is actively engaged in developing a new sewage system for the 20-24 residences of Grand Portage, and that the National Park Service anticipates connecting to the new system when completed. It is hoped this project will be started this summer.

> "I hope that this statement will verify the positive action and interest in establishing anti-pollution practices as undertaken by the National Park Service. We consider this a continuing program, and hope that strong recommendations, as well as legislation that can be enforced, will be forthcoming as a direct result of this meeting in Duluth."

MR. DOMINICK: We have heard previously from the Federal Water Pollution Control Administration, the U. S. Geological Survey and the U. S. Army Corps of Engineers. We would like to hear now from Mr. Robert Sharp, U. S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.

STATEMENT OF R. W. SHARP, U. S. DEPARTMENT OF INTERIOR, BUREAU OF SPORT FISHERIES AND WILDLIFE, TWIN CITIES, MINNESOTA

MR. SHARP: Mr. Chairman, conferees, ladies and gentlemen:

I am Robert W. Sharp, representing the Bureau of Sport Fisheries and Wildlife of the Department of the Interior.

Mr. Chairman, we have a statement that I will render for the record in total, but in the interest of time-saving I will delete reading portions of it.

R. W. Sharp

The unique character of Lake Superior is well known to most of this assembly, and indeed most of us are here because of our interest in maintaining its unique qualities. When our forebearers first came upon the scene, they found one of the best quality fisheries the world has ever known, or is likely to know again. Its lake trout and whitefish brought premium prices in the leading fish markets of the Nation. Its unusual limnological features attracted the interest of scientists the world over, and still continues to do so. We in the Bureau of Sport Fisheries and Wildlife believe this resource is worthy of a maximum conservation effort to preserve.

Precise figures on the sport fishery use of Lake Superior are not yet available, but are in preparation. Angling pressure per acre is, of course, light in comparison with other leading fishing waters, but fishermen coming to Lake Superior are seeking an angling experience that can be duplicated in few other waters. An estimated 1.4 million vacationists visited the basin in 1964. We can assume that a substantial number of these visitors came to fish.

The major fishery investigations of Lake Superior have been conducted by our sister agency, the Bureau of Commercial Fisheries. This agency will make its statement following my own.

R. W. Sharp

Due to the interstate and international character of Lake Superior, certain fishery responsibilities are vested in the Great Lakes Fishery Commission and its various committees.

The Bureau of Sport Fisheries and Wildlife has since the late 1950's made a major effort in the propagation phase of the lake trout restoration program. Since that time the Bureau has reared and stocked 11,993,000 lake trout fingerlings in Lake Superior, from its hatcheries in Michigan.

The total magnitude of this fish-stocking effort can be judged from the total stocking of lake trout from 1952 to 1968, a total stocking of 21.8 million fish, a cooperative venture between the three States here present, the Province of Ontario, and the Bureau of Sport Fisheries and Wildlife. This effort, along with that in Lake Michigan, has been one of the most intensive fish-stocking ventures ever attempted. The continuing success of these efforts will depend to a considerable degree on the maintenance of top quality water in Lake Superior.

Since 1966 the Bureau has worked closely with the three States here present in the anadromous fish program, utilizing funds available under the Anadromous Fish Act of 1965.

The major effort here has been in the area of facilities to improve or establish runs of coho salmon, chinook salmon, and rainbow trout. Since its inception, the three States involved have planned expenditures of $2,160,000, in measures and improvements to aid the Lake Superior anadromous fishery, even in this day and age a substantial fishery budget. The phenomenal success of the coho salmon fishery in Lake Michigan has given the Lake Superior program additional impetus.

For many years prior to a formal anadromous fish program the "steelhead" run in Lake Superior tributary streams has been an important adjunct to the fisheries of Minnesota, Wisconsin, and Michigan. The Minnesota "steelhead" fishery involves 56 streams along the North Shore, a number of which flow into the area affected by taconite tailings. Minnesota Department of Conservation data indicate these streams provide opportunities for an average of 1,000 fishermen per mile during the angling season. Fish taken average about 4 pounds in weight. Similar fisheries are found in many of the Lake Superior tributary streams of Wisconsin and Michigan.

Typically, young "steelhead" spend 2 years in the stream before migrating to the open lake where they grow to adult size in about 2 more years and return to their home stream to spawn. Although little is known of their lake life history, it is apparent that they are fish of the more shallow waters from 6 to 60 feet in depth. Along the North Shore the growing and maturing "steelhead" are limited to a very narrow zone. The importance of this shallow shore zone in the life history of Lake Superior fishes has been stressed in other presentations.

The characteristics of the North Shore topology are well demonstrated on the map to my left (indicating).

R. W. Sharp

1. Taconite wastes are not acutely toxic to fingerling-size coho salmon, rainbow trout, white suckers, black bullheads, bluegills, and yellow perch in 96-hour, static bioassays.

2. Taconite wastes are not lethal to eyed eggs of rainbow trout and apparently have no harmful effect on the hatchability of the eggs.

3. High concentrations of taconite wastes cause mortalities among sac fry of rainbow trout in 4-day exposures.

4. Taconite wastes are not acutely toxic to backswimmers, midge larvae, and water-fleas in 96-hour bioassays.

5. Taconite wastes should be bioassayed against sac fry of lake trout and other salmonids which live and spawn in Lake Superior.

6. Whereas strong concentrations of taconite have little acute effects on fish and aquatic invertebrates, there are possibilities for chronic and other effects. Long-term bioassays in flowing systems would be required to demonstrate chronic toxicities to aquatic life due to heavy metals, mechanical damage to gills by particulate taconite, and repellency to fish.

Mr. Chairman, I will read the conclusions from Appendix 2 of the Fish Control Laboratory of La Crosse, Wisconsin, May 1969.

MR. DOMINICK: Appendix 2 will be included in the record in its entirety.

R. W. Sharp

The basic productivity of Lake Superior is lower than that of most other lakes and data have been presented to indicate that tailings have a measurable detrimental effect on production of basic fish food organisms. It is conceivable, therefore, that growth and production of "steelhead" southeast of the Reserve plant will be affected. No information is available to permit a quantitative estimate on the degree of damage to this fishery.

In connection with earlier studies of the effect of taconite wastes on fish and other aquatic organisms, the Fish Control Laboratory of the Bureau of Sport Fisheries and Wildlife, at La Crosse, Wisconsin, conducted a series of bioassays involving several species of test fish, and other aquatic organisms. The results of these studies are set forth in Appendix 1 and 2.

Mr. Chairman, in the interest of time-saving, I will read only the conclusions from these two appendices.

MR. DOMINICK: That will be fine, Mr. Sharp. Do all of the conferees have the appendices?

MR. SHARP: They are attached to the copy I gave to you.

MR. DOMINICK: The Appendices will be included in the record in its entirety.

MR. SHARP: Appendix 1 is dated October 1968, in La Crosse, Wisconsin. I will read only the conclusions.

R. W. Sharp

MR. SHARP: Conclusions:

1. High concentrations of taconite wastes cause mortalities among sac fry of rainbow trout and lake trout in 4-day exposures.

2. Sac fry of lake trout appear more susceptible than sac fry of rainbow trout to taconite wastes, but the test conditions were more conducive to the survival of rainbow trout.

3. Green and eyed lake trout eggs exposed to the taconite waste died faster than controls in 20-day exposures. Green and eyed rainbow trout eggs were less affected by the taconite effluent.

4. The rainbow trout sac fry died at concentrations of taconite waste and exposures very similar to those reported in previous tests, i.e. those included in Appendix 1.

MR. DOMINICK: Mr. Sharp, before you leave the studies that you have discussed here, it appears that there are some inconsistencies between the summary of results of the studies contained in Appendix 1 with those contained in Appendix 2. Is that only an appearance or is that your conclusion as well?

MR. SHARP: Mr. Chairman, as I mentioned, I did not conduct nor direct this work and these appendices are submitted directly to me from our La Crosse Laboratory. I think the discrepancies are based upon the fact that the bioassays are not complete, as they point out.

MR. DOMINICK: Turning to Appendix 1, Conclusion No. 3, you say, "High concentrations of taconite wastes cause mortalities among sac fry of rainbow trout in 4-day exposures." Do you have backup material to show what is meant by "high concentrations"?

MR. SHARP: Yes. I think this is well explained in the body of the report. If you will turn to Page 8, in general these tests were conducted at levels of 10, 25, 50, and 75 percent concentrations of taconite, with the mortalities becoming relatively higher as the amount of taconite in the solutions increased. I think this is quite clearly set forth if you read the entire body of the report.

MR. DOMINICK: Are there any other questions on this point?

MR. PURDY: Yes.

When you say taconite waste, is this the unsettled taconite wastes, including the suspended solids and all?

MR. SHARP: Yes, the unsettled waste as it is issued from the plant. A hundred percent solution came from the discharge.

MR. DOMINICK: Have you cooperated in any way with the Water Quality Lab in carrying out these studies?

MR. SHARP: Dr. Mount, can you answer that question for me, please?

He is out of the room.

Yes. In general, without having all of the details, there was some level of cooperation between the two laboratories.

MR. DOMINICK: I hope that will continue and we will press on with trying to resolve any inconsistencies which may appear here.

MR. SHARP: Dr. Mount can give more details on this than I can. He may, if he wishes, answer questions at a later time.

MR. DOMINICK: Thank you.

Are there any other questions?

(No response.)

MR. DOMINICK: You may proceed.

MR. SHARP: Pollution from some of the major tributaries has been of some consequence and should be considered in these proceedings.

I will pass over this portion of our submission, Mr. Chairman.

The system has been passed on by several previous speakers, notably by Dr. Bartsch.

The importance of the high quality water being discharged into the lower lakes should be considered in these deliberations. The rapid decline in the quality of Lake Erie over the past 20 years has been widely documented. If there is any hope of restoring the quality of Lake Erie, the waters to do so must come from Lake Superior via the St. Marys River and subsequent discharge through Lake Huron and Lake St. Clair. The average discharge of 73,100 CFS from the St. Marys River has a marked effect on the ecology of the lower lakes. Studies of Lake Superior water quality have not yet been sufficiently detailed to determine how far we may permit the addition of heat, silt, nutrients, heavy metal salts, or other pollutants, without sacrificing this important aspect of Lake Superior in relation to the Great Lakes ecosystem.

In summary, then, we see subtle changes taking place in Lake Superior that are not easy to document; locally, at least, increased turbidity, pollution of some tributaries and estuaries, and some indication of an increasing concentration of heavy metal salts. The meaning of these changes should be documented and as soon as possible. Our interest in the lake trout restoration, the anadromous fish program, and the water quality necessary to support them has been expressed.

The Bureau of Sport Fisheries and Wildlife strongly supports the conclusions reached and the recommendations made in the FWPCA report "An Appraisal of Water Pollution in the Lake Superior Basin." The Bureau stands ready to aid in the implementation of these recommendations to the limit of our assigned authority.

In particular, we stress the need for the adoption and enforcement of the proposed water quality criteria for the open waters of Lake Superior, and for the continuing surveillance of the taconite waste disposal operations of the Reserve Mining Company.

Mr. Chairman, that concludes the statement of the Bureau of Sport Fisheries and Wildlife. Thank you.

MR. DOMINICK: Thank you very much for your presentation.

Are there any questions?

(No response.)

MR. DOMINICK: Mr. Sharp, I have noted in the newspapers that planting of coho salmon has been or will be undertaken in Superior waters near here in the very near future. Could you describe these plantings?

MR. SHARP: Perhaps very briefly. This is, of course, a State of Minnesota program. As I understand it, the first plant of coho salmon is being accomplished this week in French River with subsequent stockings to take place over the next few weeks, reaching a total figure of 80,000 cohos.

Some of the Minnesota Fisheries people are here.

MR. DOMINICK: Mr. Badalich indicated this was today. Is this the first time they have been introduced in Lake Superior?

MR. SHARP: The first time on the North Shore; no, the first introduction in Lake Superior.

The State of Michigan has made coho plants along their South Shore streams.

MR. DOMINICK: What have been the results of plantings in Lake Michigan? I understand that reproduction is not accomplished and that replantings are required.

MR. SHARP: Mr. Chairman, this is a story in itself, as most of the audience knows. The phenomenal success of the coho introduction in Lake Michigan have been documented in the press, popular publications, nation-wide.

As I understand it, the State of Michigan is proceeding with their coho introduction program. They are, I believe, prepared to accept the lack of natural reproduction and consider this as largely a hatcher program with a rather phenomenal return on the level of 20 percent or more.

MR. DOMINICK: But there is lack of natural reproduction in Michigan?

MR. SHARP: To some degree, I believe. Again, I would refer this question to the Michigan Department of Conservation. Are any of their fishery people here to answer?

MR. PURDY: Mr. Chairman, it was never expected that the natural reproduction would sustain the coho fisheries program in Lake Michigan. It was anticipated in the beginning this would be a hatcher program. Natural reproduction has occurred in excess of what was originally anticipated, but the reproduction takes place in the tributary streams and not in the lake itself.

MR. DOMINICK: Thank you.

Do you expect a high rate of reproduction in Lake Superior?

MR. SHARP: I think that we might expect approximately the same rate of reproduction that we are getting in Lake Michigan. I have no other assumption.

MR. DOMINICK: So the critical factor here is the availability of spawning grounds as opposed to water quality?

MR. SHARP: I am not sure I understand your question.

MR. DOMINICK: As I understand it, the reproductive rates are determined by the availability of spawning grounds in the tributaries?

MR. SHARP: Yes, that is correct. If these fish are to reproduce, it will be in the esturaries of the North Shore streams which most of you know are limited by falls within the first mile or two, so the total spawning sights available will be limited.

I am advised that Minnesota is constructing bypass feautres, at least on the French River, to get the coho beyond the first area of falls which will materially increase the spawning area available on the French River.

If I am wrong, will you correct me, Dr. Moyle?

DR. MOYLE: That is correct.

MR. SHARP: Thank you.

MR. PURDY: Again, this is primarily a hatchery program. A critical part in this is the egg collection and then having eggs that will hatch within the hatchery. It is not expected in Michigan that natural reproduction will take place, but, to the extent necessary to maintain the resources, in the fall of each year we will have to go through an egg collection process. The critical part is to have eggs that will hatch under controlled hatchery conditions.

MR. DOMINICK: Thank you for that educational interlude for the Chairman.

(The statement of R. W. Sharp in its entirety follows:)

Statement
Presented By

THE BUREAU OF SPORT FISHERIES AND WILDLIFE
DEPARTMENT OF THE INTERIOR
at the Lake Superior Enforcement Conference

Duluth, Minnesota
May 13-16, 1969

Introduction

The unique character of Lake Superior has been well documented in earlier presentations, is well known to most of this assembly and indeed most of us are here because of our interest in maintaining its unique qualities. When our forebearers first came upon the scene, they found one of the best quality fisheries the world has ever known, or is likely to know again. Its lake trout and whitefish brought premium prices in the leading fish markets of the nation. Its unusual limnological features attracted the interest of scientists the world over, and still continues to do so. We in the Bureau of Sport Fisheries and Wildlife believe this resource is worthy of a maximum conservation effort to preserve.

Sport Fishing Use - Precise figures on the sport fishery use of Lake Superior are not yet available, but are in preparation. Angling pressure per acre is light, in comparison with other leading fishing waters, but fishermen coming to Lake Superior are seeking an angling experience that can be duplicated in few other waters. An estimated 1.4 million vacationists visited the basin in 1964. We can assume that a substantial number of these visitors came to fish.

Bureau Interests

The major fishery investigations of Lake Superior have been conducted by our sister agency, the Bureau of Commercial Fisheries, and due to its interstate and international character, certain fishery responsibilities are vested in the Great Lakes Fishery Commission, and its various committees.

The Bureau of Sport Fisheries and Wildlife has, since the late 1950's, made a major effort in the propagation phase of the lake trout restoration program. Since that time, the Bureau has reared and stocked 11,933,000 lake trout fingerlings in Lake Superior, from its hatcheries in Michigan. The total magnitude of this fish stocking effort can be judged from the total stocking of lake trout from 1952 to 1968, 21,800,000 fish, a cooperative venture between the three States, the Province of Ontario, and the Bureau of Sport Fisheries and Wildlife. This effort, along with that in Lake Michigan, has been one of the most intensive fish stocking ventures ever attempted. The continuing success of these efforts will depend to a considerable degree on the maintenance of top quality water in Lake Superior.

Details of the Lake Superior stocking are presented in Table 1. (Page 3)

TABLE 1

LAKE TROUT PLANTINGS IN LAKE SUPERIOR
1952-1968

Year	Bureau	State	Province
1952-59		1,900,497	
1960	500,000	549,800	
1961	451,575	253,000	554,180
1962	855,000	490,000	508,000
1963	1,265,000	569,000	477,000
1964	1,196,000	963,000	472,000
1965	910,000	616,000	468,000
1966	2,073,249	778,800	450,000
1967	2,242,057	289,000	500,000
1968	2,501,000		
Totals	11,993,881	6,409,097	3,429,180

GRAND TOTAL 21,832,158

Anadromous Fish Program

Since 1966, the Bureau has worked closely with the States of Minnesota, Michigan and Wisconsin in the anadromous fish program, utilizing funds available under the Anadromous Fish Act of 1965.

The major effort here has been in the area of facilities to improve or establish runs of such anadromous fish as coho, and chinook salmon, and the rainbow trout. Since its inception, the three States involved have planned expenditure of $2,160,000 *, in measures and improvements to aid the Lake Superior fishery, even in this day and age a substantial fishery budget. The phenomenal success of the coho salmon project in Lake Michigan has given the Lake Superior program additional impetus.

*Michigan	$1,798,000
Wisconsin	218,000
Minnesota	144,000
	$2,160,000

For many years, prior to a formal anadromous fish program, the "steelhead" run in Lake Superior tributary streams has been an important adjunct to the fisheries of Minnesota, Wisconsin and Michigan. The Minnesota "steelhead" fishery involves 56 streams along the North Shore, a number which flow into the area affected by taconite tailings. Minnesota Department of Conservation data indicate these streams provide opportunities for an average of 1,000 fishermen per mile during the angling season. Fish taken average about four pounds. Similar fisheries are found in many of the Lake Superior tributary streams of Wisconsin and Michigan.

Typically, young steelhead spend two years in the stream before migrating to the open lake, where they grow to adult size in about two more years and return to their home stream to spawn. Although little is known of their lake life history, it is apparent that they are fish of the more shallow waters from 6 to 60 feet in depth. Along the North Shore the growing and maturing steelhead are limited to a very narrow zone. The importance of this shallow shore zone in the life history of Lake Superior fishes has been stressed in other presentations.

The basic productivity of Lake Superior is lower than that of most other lakes and data have been presented to indicate that tailings have a measurable detrimental effect on production of basic fish food organisms. * It is conceivable, therefore, that growth and production of steelhead southeast of the Reserve plant will be affected. No information is available to permit a quantitative estimate on the degree of damage to this fishery.

*Minnesota Conservation Dept. Ref. #54.

In connection with earlier studies of the effect of taconite wastes on fish and other aquatic organisms, the Fish Control Laboratory of the Bureau of Sport Fisheries and Wildlife conducted a series of bioassays involving several species of test fish, and other aquatic organisms. The results of these studies are set forth in Appendix 1 and 2.

Pollution from some of the major tributaries has been well documented by other speakers, and I will pass over this portion of our submission.

Ecosystem Aspects of Lake Superior Pollution

These aspects have been touched on by Dr. Bartsch. The importance of the high quality water being discharged into the lower lakes should be considered in these deliberations. The rapid decline in the quality of Lake Erie over the past 20 years has been widely documented. If there is any hope of restoring the quality of Lake Erie, the waters to do so must come largely from Lake Superior via the St. Marys River and subsequent discharge through Lake Huron and Lake St. Clair. The average discharge of 73,100 CFS from the St. Marys River has a marked effect on the ecology of the lower lakes. Studies of Lake Superior water quality have not yet been sufficiently detailed to determine how far we may permit the addition of heat, silt, nutrients, heavy metals or other pollutants, without sacrificing this important aspect of Lake Superior in relation to the Great Lakes ecosystem.

Summary

We see subtle changes taking place in Lake Superior that are not easy to document; logically at least, increased turbidity, pollution of some tributaries and estuaries, and some indication of an increasing concentration of heavy metals. The meaning of these changes should be documented, and as soon as possible. Our interest in the lake trout restoration, the anadromous fish program and the water quality necessary to support them has been expressed.

The Bureau of Sport Fisheries and Wildlife strongly supports the conclusions reached and the recommendations made in the FWPCA report, "An Appraisal of Water Pollution in the Lake Superior Basin". The Bureau stands ready to aid in the implementation of these recommendations to the limit of our assigned authority.

In particular, we stress the need for the adoption and enforcement of the proposed water quality criteria for the open waters of Lake Superior, and for the close continuing surveillance of the taconite waste disposal operations of the Reserve Mining Company.

Robert W. Sharp

Attachments: (2)
Appendix 1
Appendix 2

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF SPORT FISHERIES AND WILDLIFE

BIOASSAYS OF TACONITE WASTES AGAINST FISH AND OTHER AQUATIC ORGANISMS

by

Leif L. Marking, Chemist

and

Robert E. Lennon, Director

Fish Control Laboratories
La Crosse, Wisconsin
October 1968

INTRODUCTION

Taconite wastes from the Reserve Mining Company, Silver Bay, Minnesota, were tested for short-term toxic effects on fish, fish eggs, sac fry, and several species of aquatic invertebrates at the request of the USDI Taconite Study Group. The first samples of taconite waste arrived at the Fish Control Laboratory in April 1968, and an attempt was made to accomplish as much pertinent testing as possible before the October 1968 deadline. The brief period, however, limited the number of species which could be included.

The waste is principally taconite rock and contains heavier solids which settle out readily, finer particles which remain in suspension, and water. The water fraction is pumped into the Plant and used to transport taconite through an extraction process and carry wastes out into Lake Superior. The nature of the waste materials and a description of the disposal site are fully detailed in reports by other agencies in the Taconite Study Group.

METHODS AND MATERIALS

Standard bioassay methods of the Fish Control Laboratory were followed in performing the short-term, static tests on taconite wastes (Lennon and Walker, 1964)[1/] at 12° C. Five-gallon samples of waste

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[1/] Lennon, Robert E. and Charles R. Walker
1964. Investigations in Fish Control. 1. Laboratories and methods for screening fish-control chemicals. U.S. Bureau of Sport Fisheries and Wildlife, Circular 185: 15 p.

effluent were stirred thoroughly before they were proportioned and diluted with reconstituted, deionized water to obtain the desired concentrations and volumes.

Our analysis of an undiluted sample of taconite effluent on April 29, 1968, disclosed the following: total alkalinity, 42.0 p.p.m.; total hardness, 48.0 p.p.m.; calcium hardness, 32.0 p.p.m.; total iron, 2.20 p.p.m.; manganese, 0.14 p.p.m.; calcium ion, 1.65 p.p.m.; magnesium ion, 2.70 p.p.m.; copper ion, 0.11 p.p.m.; and zinc ion, 0.025 p.pm. The ion analyses were done by atomic absorption spectroscopy.

The seven species of fish, 1 to 4 inches long, and the rainbow trout eggs were obtained from national and state fish hatcheries (table 1). The first fish eggs were in the eyed stage when introduced into the bioassays, and they hatched several days later while the tests were in progress. Another group of eggs was held until hatching, and the sac fry were then used in bioassays.

The aquatic invertebrates were collected from our own holding pools.

Several of the acute toxicity tests against fish and invertebrates, and all of the tests against eggs and sac fry were extended beyond the normal, 96-hour observation period to detect any possible effects. The extended bioassays were aerated, but no feed was furnished to the fish during any of the tests. The high degree of turbidity in the vessels required that the solutions be decanted daily so that mortalities could be observed and recorded.

Table 1:- A list of fish and aquatic invertebrates used in bioassays of taconite wastes.

Common name	Scientific name
FISH	
Coho salmon	*Oncorhynchus kisutch*
Rainbow trout	*Salmo gairdneri*
Lake trout	*Salvelinus namaycush*
White sucker	*Catostomus commersoni*
Black bullhead	*Ictalurus melas*
Bluegill	*Lepomis macrochirus*
Yellow perch	*Perca flavescens*
AQUATIC INSECTS	
Backswimmer	*Notonecta* sp.
Midge larva	*Chironomus* sp.
CRUSTACEAN	
Water-flea	*Daphnia* sp.

RESULTS

Fish

Small coho salmon, rainbow trout, lake trout, white suckers, black bullheads, bluegills and yellow perch exhibited no acute responses during 96-hour exposures to undiluted taconite waste. This undiluted medium was extremely turbid. During the course of the tests, large amounts of dense particulate matter settled to the bottom of bioassay vessels, leaving gray colloidal material in suspension. The dissolved oxygen was sufficient for the fish in the taconite medium, but higher concentrations were measured in control media.

During extended bioassays, coho salmon and lake trout survived in undiluted taconite effluent for three weeks, and the fish appeared to be as healthy as controls maintained in clean water. On the other hand, rainbow trout perished within the three weeks in media containing 75 percent and 100 percent of taconite effluent, whereas control rainbows did not begin to die until after 25 days. The cause of death of the rainbows was starvation, but those fish in taconite media died sooner because of added stress and/or lower dissolved oxygen.

Trout eggs and fry

Eyed eggs of rainbow trout appeared unaffected in solutions of taconite waste, but the sac fry hatching from these eggs in the bioassay media were sensitive to dilutions which contained 25 percent or more of the waste (table 2). In the first trial, the eggs were exposed for seven days prior to hatching, and there was little mortality at all dilutions. The newly-hatched sac fry from these eggs, however, died at dilutions of 10, 25, and 50 percent in one week.

In a confirming trial, the eggs hatched within four days in the bioassay media, and the sac fry succumbed within one week in dilutions of 25, 50, 75, and 100 percent of taconite effluent.

Table 2:- Mortality of eggs and sac fry of rainbow trout in dilutions of taconite waste at 12° C.

Exposure (days)	Accumulated mortality among 50 (trial 1) and 25 (trial 2) at concentrations of							
	0 percent	1 percent	5 percent	10 percent	25 percent	50 percent	75 percent	100 percent
Trial 1. Fifty eggs per dilution.								
5	3	4	2	3	2	1	--	--
7[1/]	3	4	2	4	4	2	--	--
10	6	5	11	7	23	20	--	--
15	17	50	29	50	50	50	--	--
20	20	50	29	50	50	50	--	--
Trial 2. Twenty-five eggs per dilution.								
4[1/]	0	--	--	2	1	1	0	2
6	1	--	--	3	4	8	7	17
8	2	--	--	8	5	21	16	22
11	3	--	--	8	5	23	22	23
15	3	--	--	9	25	25	25	24
20	3	--	--	9	25	25	25	24

[1/] Eggs began to hatch

The sac fry in the first trial appeared to be more sensitive to the waste than those in the second trial. The fact that the eggs in the first test were exposed longer to the taconite prior to hatching may have been a contributing factor.

Sac fry approximately four days old were placed in dilutions of taconite effluent. They responded more rapidly to dilutions of 50 percent or more than sac fry emerging from eggs already in the test solutions (table 3). Within two days, 24 out of 25 sac fry perished in undiluted effluent, and the rate of mortality was high within four days in the 50- and 75-percent dilutions. In contrast, there were only two mortalities among controls in clean water in 20 days.

The cause of death of sac fry in taconite effluent is not known. Starvation is not a principal factor because fry in this stage of life obtain nourishment from the yolk sac.

Aquatic Invertebrates

Backswimmers and midge larvae were exposed to undiluted effluent for 13 days. They survived as well as specimens in control vessels.

Water-fleas (Daphnia sp.) showed stress within one week in undiluted effluent. They surfaced frequently in the thick suspension of taconite waste and gradually became inactive. All disappeared within 20 to 24 days, but specimens in control vessels survived. The test indicates no acute toxicity of the waste, but suggests a chronic effect.

Table 3:- Mortality of rainbow trout sac fry in dilutions of taconite waste at 12° C.

Exposure (days)	Accumulated mortality among 25 sac fry at concentrations of					
	0 percent	10 percent	25 percent	50 percent	75 percent	100 percent
1	0	0	0	0	0	0
2	0	1	2	7	11	24
4	0	2	4	25	24	24
6	0	3	11	25	25	24
10	0	3	11	25	25	24
20	2	4	11	25	25	24

DISCUSSION

Sac fry of rainbow trout are more sensitive to the ore waste than eyed eggs, fingerling salmonids and other fish, and aquatic invertebrates. Thus, from the standpoint of harmfulness, taconite may have a direct and relatively acute effect on the sac fry of salmonid fish. Admittedly, rainbow trout spawn in streams, and their sac fry could not be exposed to Reserve Mining Company's effluent. The rainbow was used in these tests, however, because it is the only salmonid that we could obtain in sac fry stage during the April-October period of the investigation.

An attempt will be made this fall (1968) to detect the effects of taconite effluent on sac fry of lake trout, a species which spawns in Lake Superior. The results will be included in an Addendum to this report to the Taconite Study Group. Tests of taconite should also be made against sac fry of lake herring (*Coregonus artedii*) and the bloater (*Coregonus hoyi*) because these species spawn in areas of the Lake Superior which may be exposed to taconite wastes.

The trout and salmon in the bioassays appeared to exhibit restlessness and irritation in the presence of taconite waste. This behavior suggests that salmonids would avoid water contaminated by the waste.

The fact that our short-term, static bioassays did not demonstrate acute damage by taconite waste on fingerling-size fish cannot be construed to mean that taconite is harmless to fish. The 96-hour bioassay is only a first step in determining the effect of a substance on fish. When warranted, as in the case of taconite disposal into Lake Superior, the short-term bioassay should be followed by long-term, flowing-type bioassays to detect chronic effects of taconite waste on fish. Whereas the long-term bioassays may produce better and more complete information, they are difficult and expensive to set up and maintain.

The reaction of water-fleas to taconite was inconclusive. The mortality of organisms may have been due to toxicity, starvation, mechanical damage, or other factors associated with over-extension of a short-term test.

CONCLUSIONS

1. Taconite wastes are not acutely toxic to fingerling-size coho salmon, rainbow trout, white suckers, black bullheads, bluegills, and yellow perch in 96-hour, static bioassays.
2. Taconite wastes are not lethal to eyed eggs of rainbow trout and apparently have no harmful effect on the hatchability of the eggs.
3. High concentrations of taconite wastes cause mortalities among sac fry of rainbow trout in 4-day exposures.
4. Taconite wastes are not acutely toxic to backswimmers, midge larvae, and water-fleas in 96-hour bioassays.
5. Taconite wastes should be bioassayed against sac fry of lake trout and other salmonids which live and spawn in Lake Superior.
6. Whereas strong concentrations of taconite have little acute effects on fish and aquatic invertebrates, there are possibilities for chronic and other effects. Long-term bioassays in flowing systems would be required to demonstrate chronic toxicities to aquatic life due to heavy metals, mechanical damage to gills by particulate taconite, and repellency to fish.

APPENDIX 2

U.S. DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
BUREAU OF SPORT FISHERIES AND WILDLIFE

TOXIC EFFECTS OF TACONITE WASTES AGAINST EGGS AND SAC FRY OF RAINBOW AND LAKE TROUT

by
Leif L. Marking, Chemist

Fish Control Laboratory
La Crosse, Wisconsin
May, 1969

INTRODUCTION

Taconite wastes from the Reserve Minining Company, Silver Bay, Minnesota, were tested against several life stages of rainbow trout and other aquatic organisms in static bioassays at the Fish Control Laboratory, La Crosse, Wisconsin. The report[1] indicates no harmful effects on the hatchability of eggs and no acutely toxic effects to fingerling fish or aquatic insects. However, the data suggest that sac fry, an early life-stage of fish, die in high concentrations of the waste solutions. The investigations were limited to rainbow trout. This species is most apt to spawn in tributaries of Lake Superior and, therefore, the fry are not likely to be present in the taconite disposal areas. For this reason, we elected to expand our studies to include eggs, sac fry, and young fingerlings of lake trout which do inhabit Lake Superior. In addition, eggs and fry of rainbow trout were tested to confirm the original data.

METHODS AND MATERIALS

Standard bioassay methods of the Fish Control Laboratory were followed in performing the short-term, static tests on taconite wastes (Lennon and Walker, 1964)[2/] at 12° C. Five-gallon samples of waste effluent were stirred thoroughly before they were proportioned and diluted with reconstituted, deionized water to obtain the desired concentrations.

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[1] Leif L. Marking and Robert E. Lennon
Bioassays of Taconite Wastes Against Fish and Other Aquatic Organisms. Presented to the U.S.D.I. Taconite Study Group, Duluth, Minnesota, October, 1968.

Twenty-five eggs or fry of rainbow trout (Salmo gairdneri) or lake trout (Salvelinus namaycush) were placed in each 1-gallon jar containing 2.5 liters of diluted effluent. The effluent was diluted with standard reconstituted water to obtain concentrations lower than the pure effluent. The control organisms were tested in reconstituted water. The bioassays were observed and the mortalities recorded every four days. Dead individuals were removed after each observation. Green eggs of lake trout were disturbed less often since they are more sensitive to handling. The data are reported for 20-day exposures although some of the tests were extended beyond this time. The supernatant was decanted in the highly turbid bioassays in order to accurately record mortality.

The rainbow trout eggs were obtained from the National Fish Hatchery, Manchester, Iowa, on the day of spawning. Green lake trout eggs were furnished by the State Fish Hatchery, Westfield, Wisconsin.

[2/] Lennon, Robert E. and Charles R. Walker
1964. Investigations in Fish Control. 1. Laboratories and methods for secreening fish-control chemicals. U.S. Bureau of Sport Fisheries and Wildlife, Circular 185: 15 p.

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RESULTS

Green and eyed eggs of rainbow trout survived short exposures to all concentrations of taconite waste (table 1). The control eggs survived equally well. The eyed eggs appear more sensitive to the effluent during and shortly after the hatching period. The eyed eggs began hatching 12 days after the beginning of the bioassay. The sac fry resulting from the eggs in the pure effluent were completely eliminated after 20 days of exposure.

Newly hatched sac fry of rainbow trout appear sensitive to high concentrations of taconite effluent in 4-day exposures (table 1, trial 3). After 20 days of exposure, all of the controls survived while concentrations of 50 percent and greater killed the sac fry.

Green and eyed lake trout eggs appear more susceptible to taconite than rainbow trout eggs (table 2, trial 1 and 2). In 20 day exposures, all of the green eggs and most of the eyed eggs were eliminated at all concentrations. Fourteen of the control eggs in trial 1, and 15 of the eggs in trial 2 also died during this exposure.

Newly hatched fry of lake trout are quite sensitive to the taconite effluent. All were destroyed within 4 days at concentrations of 25 percent or greater (table 2, trial 3). After 20 days, Table 1.--Mortality among 25 eggs or 25 sac fry of rainbow trout in dilutions of taconite waste at 12° C.

Exposure (days)	Accumulated mortality at concentrations of 0 percent	10 percent	25 percent	50 percent	75 percent	100 percent
Trial 1, Green eggs						
4	0	0	0	0	0	0
8	5	2	2	3	2	7
12	5	14	16	15	13	12
16	8	15	17	17	19	19
20	12	16	17	17	21	21
Trial 2, Eyed Eggs						
4	0	0	0	0	0	0
8	0	0	0	0	0	0
12[1]	2	0	0	0	4	2
16	5	0	0	0	6	4
20	6	1	1	0	7	25
Trial 3, Newly hatched sac fry						
4	0	0	0	3	25	11
8	0	0	0	4	25	25
12	0	0	0	7	25	25
16	0	0	0	8	25	25
20	0	0	0	8	25	25

[1] Starting to hatch

Table 5.--Mortality among 25 eggs or 25 sac fry of lake trout in dilutions of taconite waste at 12° C.

Exposure (days)	Accumulated mortality at concentrations of					
	0 percent	10 percent	25 percent	50 percent	75 percent	100 percent
Trial 1, Green eggs						
5	0	0	0	0	0	0
10	5	5	8	12	11	24
15	10	10	14	24	17	25
20	14	25	25	25	25	25
Trial 2, Eyed eggs						
4	0	0	0	0	0	0
8	3	0	25	5	13	22
12	9	10	25	20	24	25
16	14	14	25	22	24	25
20	14	18	25	23	25	25
Trial 3, Newly hatched fry						
4	3	2	25	25	25	25
8	3	6	25	25	25	25
12	3	8	25	25	25	25
16	8	16	25	25	25	25
20	15	25	25	25	25	25
Trial 4, Three week old fry						
4	0	0	0	1	1	5
8	0	0	1	2	3	7
12	0	1	2	2	4	7
16	0	1	2	2	4	7
20	0	1	2	2	4	7

mortality was complete in the 10-percent concentration, but 1%
of the controls were still alive.

Three-week-old lake trout fry are more resistant to the taconite effluent than any of the earlier life stages. The controls and most fry exposed to taconite survived for 20 days.

DISCUSSION

The lake trout eggs and fry appear more sensitive to the taconite than rainbow trout eggs and fry. In most cases, more than 50 percent of the control lake trout eggs or fry died. The temperature and other test conditions may have influenced their susceptibility. Usually lake trout are hatched in fresh water at temperatures colder than 12 C. The slow maturing lake trout eggs were perhaps stressed under our static testing procedures.

Many of the tests were extended to 30 days. The data were not presented, however, because most of the lake trout eggs or newly hatched fry exposed to the taconite were eliminated prior to this time. In the static bioassays longer than 20 days the controls and any remaining exposed fish began dying at a faster rate. Apparently lake trout are more difficult to rear in early life stages and require special temperature and culturing conditions.

CONCLUSIONS

1. High concentrations of taconite wastes cause mortalities among sac fry of rainbow trout and lake trout in 4-day exposures.

2. Sac fry of lake trout appear more susceptible than sac fry of rainbow trout to taconite wastes, but the test conditions were more conducive to the survival of rainbow trout.

3. Green and eyed lake trout eggs exposed to the taconite waste died faster than controls in 20 day exposures. Green and eyed rainbow trout eggs were less affected by the taconite effluent.

4. The rainbow trout sac fry died at concentrations of taconite waste and exposures very similar to those reported in previous tests at this laboratory.

E. D. Premetz

MR. DOMINICK: The Bureau of Commercial Fisheries, Mr. Ernest D. Premetz.

STATEMENT OF ERNEST D. PREMETZ, DEPUTY
DIRECTOR, U. S. DEPARTMENT OF THE INTERIOR,
BUREAU OF COMMERCIAL FISHERIES, GREAT LAKES
AND CENTRAL REGION, ANN ARBOR, MICHIGAN

MR. PREMETZ: Mr. Chairman, conferees, ladies and gentlemen:

My name is Ernest D. Premetz. I am with the U. S. Department of the Interior, Bureau of Commercial Fisheries. I am Deputy Regional Director for the Great Lakes and Central Region.

Safeguarding and perpetuating the fishery resources of the Great Lakes are major responsibilities of the U. S. Fish and Wildlife Service and its Bureaus of Commercial Fisheries and Sport Fisheries and Wildlife. Any practice or series of events which threatens the abundance of fish or a useful and productive balance of fish species is of primary concern to us.

Scientists of the Bureau of Commercial Fisheries have been working with the fisheries of the Great Lakes and their environment over a period of almost 50 years. The Bureau has been in a particularly advantageous position to observe the process of change that has been taking place in this--the largest complex of fresh-water resources in the world. BCF scientists were the first to direct public attention to the now well-publicized deterioration of Lake Erie. In fact, our scientists had a pretty tough time, but, when the visible signs of pollution showed up, then everyone was on the bandwagon. You had hearings. You had all sorts of groups interested in doing something about pollution.

I hope because you don't see the visible signs in Lake Superior that you don't sit back and wait for them. Listen to the scientists. They will tell you when the subtle signs appear and when it is time to act.

Frankly, Lake Superior presents an entirely different situation then Lake Erie and has its own unique fishery and ecological framework. In this statement we would like to summarize our position with regard to the water quality aspects of Lake Superior's fish and aquatic life resources. We would like to do this both in the context of Lake Superior itself and in terms of the entire Great Lakes ecosystem.

We are very concerned with Lake Superior. In fact, we have two field stations located on the lake -- one at Marquette, Michigan, and one at Ashland, Wisconsin. We also have a research vessel that plies this entire lake. Our station in Marquette is a center for the field operations of our sea lamprey control program which is carried on by the Bureau in U. S. waters of the Great Lakes under contract from the Great Lakes Fishery Commission.

Actually, at the present time we are getting the sea lamprey under control in Lake Superior. You have already heard that restocking is taking place. Much of the future depends, of course, on the success we continue to maintain as far as lamprey control and on water quality. In fact, all of these millions of dollars have been spent in rehabilitation programs and the Great Lakes can go down the drain if we don't do something about maintaining water quality.

At our Ashland station we are conducting many various monitoring studies on the lake trout restoration program, and we are also looking into various aspects of the lake's biota and its environment.

Fish and aquatic life play a unique role with respect to water quality problems, particularly in large and complex ecosystems as represented by the Great Lakes. As I mentioned before, long before water quality changes are detectable in gross forms and result in closed beaches and unacceptable domestic water supplies, the interactions among life of the lake can reveal the significance and rate of these changes, and can give early warning of the need for remedial action. This is particularly the case in Lake Superior where a huge volume of exceptionally high quality water has supported an aquatic life complex dominated by high quality fish with exacting environmental requirements. This complex, which is characterized by lake trout, whitefish, and lake herring, has already declined in other portions of the Great Lakes ecosystem, in significant part due to environmental deterioration.

The open waters of Lake Superior at this time are of exceptionally pure quality. Dissolved oxygen is normally near saturation at all depths and at times reaches supersaturated conditions. We have included in the report a table which shows average chemical characteristics of the open waters of Lake

Superior, illustrating both the high quality of these waters and their present exceedance of the State Water Quality Standards established as a result of the Water Quality Act of 1965.

The status of existing water quality is important to fish and aquatic life. Of much greater importance, however, is whether any trends may be discerned and what their direction may be. You have two figures also in your report which show concentrations of total dissolved solids and certain specific dissolved solids in the lake since 1890. It is apparent that change, if it has taken place, is almost undetectable. It should be emphasized that trends can be demonstrated for only a few parameters for which reliable data are available over a long period of time and that these items are not necessarily the most critical ones for fish and aquatic life.

I might add, as I mentioned earlier, we have been actively involved in the lake for 15 years and it has taken this long to get some feel for what happens to bodies of water of this type. There has been no work really anywhere in the world of this type to see how these subtle changes might blossom into full-scale pollution problems. We have this experience from Lake Erie now. We feel what we have learned there will stand us in good stead as to what we will do in other lakes.

Pesticides, for example, exhibit a different situation than dissolved solids. The work of BCF scientists shows that pesticide concentrations in Lake Superior fish are the lowest in the Great Lakes. The concentrations, however, are not inconsequential, and since they have accumulated over a relatively short span of time, projections are a cause for concern. The special capacity of high quality fish, such as salmonids, to accumulate these substances in their bodies, particularly as the fish develop into the larger size classes, has many disturbing ramifications for the future management of both commercial and sport fishing in Lake Superior.

We have done a very comprehensive study in the Great Lakes Basin during the past 3 years. We have a report which we can support for the record, summarizing all that data for Lake Superior.

MR. DOMINICK: We would be happy to receive that report as an exhibit and distributed to the conferees when it is available.

MR. PREMETZ: All right.

(The above-mentioned report is on file at FWPCA Headquarters, Washington, D. C., and the Great Lakes Regional Office, Chicago, Illinois.)

One of the things we now have to be concerned about pesticides is that it doesn't take much to cause an accumulation in fish. In Lake Michigan, for example, we find measurements in the lake in parts per trillion, and yet in some species of fish we have come up with parts per million. Many, of course, feel that they get this through their food chain; our scientists feel that a good share of it is strained through their gills -- into their bodies through their gills. So even minor quantities are cause for concern.

Experience with the other Great Lakes has shown the critical importance of the inshore water and tributary stream mouth zone from the standpoint of indicating actual or incipient environmental change. The sheer volume of the open waters of the Great Lakes can mask the accumulation of undesirable substances until the process has reached a critical stage. In the estuarine zone, indications of environmental deterioration tend to show up much earlier. Apart from its indicator role, this zone is of special importance in life histories of certain important species, particularly anadromous fish such as smelt, rainbow, brown and brook trout, coho and chinook salmon and inshore spawners such as lake herring.

Unfortunately, limnological changes in the inshore waters of Lake Superior have received relatively little study. It appears, however, that many reaches in this estuarine zone, like the open lake, presently exhibit exceptionally high water quality. It is also apparent that there have been obvious changes in localized sectors such as the Duluth-Superior area, Silver Bay, and in the vicinity of scattered population centers. Pulp mill wastes have degraded a portion of Nipigon Bay in the Canadian section of the lake.

The dry weight of plankton per cubic meter in the Apostle Island region is four to five times greater than sampled areas in the western part of the lake. Other areas of high plankton productivity are the region southeast of the Keweenaw Peninsula and east of Grand Marais, Michigan, and the northwest shore of the Keweenaw Peninsula. Information is lacking to establish causal relationships for these occurrences such as possible localized higher concentrations of nutrients. There have, however, been scattered reports of increased turbidity in the Apostle Islands area.

Lake herring populations have declined in Lake Superior from undetermined causes. Although once widely dispersed throughout all the Great Lakes, this species has some exacting environmental requirements. It was the first major fishery in Lake Erie to collapse (in the 1920's) with a strong likelihood that environmental changes were at least partially responsible for this collapse.

We found in Lake Erie, for example, over a 100-year period we had a 2° warming in water temperature. This is the fact that we believe caused the collapse of this particular species. The lake herring is, therefore, a particularly important species to watch in Lake Superior, and research on it should receive very high priority.

From the standpoint of fish and wildlife, however, all of these scattered signs of change in the inshore, estuarine zone should be read for what they are -- symptoms and warnings that decisions should be made now as to what levels of future water quality are to be achieved and steps taken accordingly.

From the fish and aquatic life standpoint, what is the proper stance with respect to Lake Superior water quality? The present exceptionally high quality water that characterizes all the open water environment and most of the estuarine zone supports a low productivity -- high value fish and aquatic life complex on a scale unmatched in the Nation. The value of this fishery complex, both commercial and sport, is high and likely to go higher as human populations increase and its scarcity value grows. It is possible to argue theoretically that carefully controlled, selected inputs of nutrients and heat into a cold oligotrophic lake could increase its productivity without significantly altering the composition of its fishery base. Given sufficient advance research and establishment of control mechanisms this approach may have merit, but, I point out, if sufficient advanced research and establishment is met.

It is the position of BCF, however, that in the present state of knowledge there should be no tinkering with the system until the research has been done and adequate provision made for orderly control. There are more than enough low value fish stocks in the lower lakes; the one thing that is not needed is increases in these stocks, particularly in Lake Superior.

One example will illustrate the delicacy of the existing ecological balance. Because of the very high clarity of Lake Superior waters which permits maximum penetration of light, the productivity of the benthic zone, the community of plant and animal forms living on the bottom, is high at depths that normally do not support such life in other lakes. This same high degree of light penetration also partially compensates for the low per unit phytoplanktonic productivity of Lake Superior waters by increasing the volume of water involved. Thus turbidity becomes a major controlling factor with a small increase being capable of eliminating a significant portion of the food chain base. This adverse effect could be multiplied if the increase in turbidity were caused by inert materials incapable of nourishing the scanty existing phytoplankton base.

In addition to the necessity for preserving the Lake Superior environment and improving its capacity to support its unique, high quality fish stocks, there is a wider framework that should be considered. High quality water from Lake Superior now enters the rest of the system down the St. Mary's River at an average rate of approximately 73,000 cfs. This major influx of essentially clean, highly oxygenated water dilutes the concentrations of dissolved solids and other substances entering from Lake Michigan (average 55,000 cfs) and exerts the dominant influence on the quality of the open waters of Lake Huron. If pollution inputs now entering Lake Erie are eventually abated, this same huge reservoir of clean water will be the major source for the flushing flows that may some day rehabilitate that lake and its fisheries.

I might add that scientists feel that in Lake Erie, if we clean up pollution, we can clean up the lake perhaps in 3 to 4 years. The flushing rate is very rapid because of the clean water that we have in Lake Superior that flows down through the system.

In Lake Michigan, we find, however, that the flushing rate may run 100 years or so, so this is really a serious problem.

From a systems standpoint, Lake Superior is the vital key to overall solution of a very complex problem. In this conference's deliberations on Lake Superior, we urge that this Great Lakes system perspective be kept in mind. Until adequate research on the fish stocks and their environment can be carried out and adequate control mechanisms established, there should be no tinkering with Lake Superior. In the meantime, the existing overall excellent water quality of the Lake should govern the standards, not the reverse.

This is all I have, Mr. Chairman. I would be happy to answer any questions.

MR. DOMINICK: Do we have any questions?

MR. FRANGOS: Yes, Mr. Chairman.

I am wondering, Mr. Premetz, if you might be able to provide us some of the reports or data you may have on findings of the Apostle Island area. I am referring to Page 7 of your statement. You are talking about the plankton concentrations 4 or 5 times higher --

MR. PREMETZ (interrputing): Yes, we can provide these data.

MR. FRANGOS: Can you also do this with respect to your statement about the scattered reports of increased turbidity in that same area?

MR. PREMETZ: Yes, we will provide that as well.

MR. FRANGOS: I am wondering, Mr. Premetz, could you help us a little bit by giving us at least your opinion of what you might consider activity that you could classify as tinkering?

MR. PREMETZ: I have heard a lot of people talk about putting nuclear powerplants on Lake Superior with the hope of creating bathing beaches. We feel that that sort of tinkering, although it might be very desirable to create bathing beaches on the shores of Lake Superior, would not be appropriate until the actual ecological impact were actually known. What would happen to our fish species that we now have in the lake?

MR. FRANGOS: But you are not suggesting that we would suspend all discharges to the lake at this time, are you?

MR. PREMETZ: No, I am not.

MR. FRANGOS: I have one other question for my own education. On page 9 when you are talking about the delicacy of the ecological balance, is it your implication here that, generally speaking, Lake Superior has a very low concentration of food materials to sustain the fishery?

MR. PREMETZ: Yes, it does. Actually, it is a relatively unproductive lake, but it does support a unique complex of fish species that don't exist elsewhere in the world.

MR. FRANGOS: Thank you.

MR. DOMINICK: Mr. Purdy?

MR. PURDY: Yes.

Mr. Premetz, in speaking of the lamprey eel control program, you departed from your prepared text and made the statement that lamprey is now under control in Lake Superior. I seem to remember some recent information that indicated that last year there were some 200 percent increase in the scarring incidence on the lake trout population by the lamprey. Would you comment on that?

MR. PREMETZ: I was hoping what I said would trigger some comments. One problem we are experiencing as far as control of the lamprey in the Great Lakes is the fact that the U. S. Government has not been in a position to fund the program to the extent that the Canadian government has been willing to fund it, and at the present time we are working on funds that we once were using for one lake i.e., Lake Superior. So much of the information we have, particularly survey-type data and the data you mentioned, has been on a very spotty basis because we must try to keep effective control with the fish stocking of predators in the lake. So much of the research that should be done has not been done.

Another thing is because of the fact that the time schedule has deteriorated on lamprey control because of lack of funds and there has been reinfestation from Lake Huron, which is now only partially controlled.

MR. PURDY: Would that be difficult to say -- that the lamprey eel is under control in Lake Superior at this time, then?

MR. PREMETZ: I would say it is a question of degree of control that you might ultimately achieve. It is under control to the extent that lake trout are surviving in the lake and reproduction is taking place in the lake, so it is a question of degree of control. Whether we will ever be able to achieve

100 percent control is a question.

MR. PURDY: You would like to see additional controls?

MR. PREMETZ: Yes, we certainly would.

MR. PURDY: O.K.

MR. DOMINICK: Mr. Premetz, on Page 3 you mentioned experience with the other Great Lakes has shown the critical importance of the inshore water and tributary stream mouth zone from the standpoint of indicating actual or incipient environmental change.

Are we gathering experience? Are we conducting any studies in Lake Superior in those inshore waters and stream mouth zones at the present time?

MR. PREMETZ: I believe the States are stepping up their work in these areas. We are doing some as well. Actually, with the introduction of the anadromous species in Lake Superior, there has been greater and greater interest in the tributary streams and in these particular zones.

MR. DOMINICK: Thank you.

Are there any other questions?

(No response.)

MR. DOMINICK: Thank you for a very good statement.

We will hear from the Bureau of Water Hygiene, U. S. Public Health Service, Dr. Graham Walton.

DR. WALTON: Mr. Chairman, conferees, ladies and gentlemen:

I am Graham Walton, Chief, Technical Services Bureau of Water Hygiene, Environmental Control Administration, U. S. Public Health Service, Cincinnati, Ohio.

First I have a statement prepared by Donald W. Marshall, Water Hygiene Representative, Environmental Control Administration, Region V, Chicago, Illinois, and Commissioner representing DHEW on the Great Lakes Commission. If I give this, it will take about 10 minutes. The statement that I have prepared is a separate statement given to water supplies only. It will take a little less than 10 minutes.

What is your desire, Mr. Chairman? I can put one in the record if you wish and give my own statement.

MR. DOMINICK: I think you should be the judge on this, Dr. Walton. Is there material in Donald W. Marshall's statement which you think will be of value to the entire audience?

DR. WALTON: I think maybe I should give Donald Marshall's statement.

MR. DOMINICK: Very well, go ahead, please.

STATEMENT OF DONALD W. MARSHALL, WATER HYGIENE REPRESENTATIVE, REGION V, CHICAGO, ILLINOIS, AND COMMISSIONER FOR DHEW ON THE GREAT LAKES COMMISSION (read by Dr. Graham Walton.)

DR. WALTON: This is a statement on health aspects of water quality for the Conference in the Matter of Pollution of Interstate Waters in the Lake Superior Basin, by Donald W. Marshall.

Statement on Health Aspects of Water Quality for the Conference in the Matter of Pollution of the Interstate Waters in the Lake Superior Basin*

by

Donald W. Marshall**

The Department of Health, Education, and Welfare, acting under the Public Health Service Act has primary Federal responsibility for protecting the health of the people. The Public Health Service has strong interest in the protection and enhancement of community water supplies, both as to adequacy and purity for water reaching the ultimate consumer. Water as it is delivered at the tap should be potable and should meet the recommended Public Health Service drinking water standards. The discharge of pollutants and waste waters to a body of water such as Lake Superior and its watershed constitutes a threat to the health of people living in the watershed and utilizing these waters for domestic supply, commercial and sports fishing, recreation, and other purposes. The health threat associated with water is of three types: chemical, biological, and radiological.

The Public Health Service has long been concerned about the quality of water. The discharge of inadequately treated municipal and industrial wastes can cause impairment of water quality in the waters of Lake Superior and its tributary basin (Michigan-Minnesota-Wisconsin). The findings of the conference report indicate that untreated and/or inadequately treated municipal and industrial wastes are being discharged to localized areas of these waters and that they could endanger the health and welfare of persons in states other than those in which such discharges originate. While the conventional water supply treatment processes are capable of removing or destroying pathogenic organisms, the presence of pathogens in raw water supplies constitutes a hazard potential which is dependent upon human or mechanical failure. Also, polluted discharges constitute a direct hazard to those using the waters for contact recreational purposes.

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* To be presented at the Conference in the Matter of Pollution of the Interstate Waters of Lake Superior and Its Tributary Basin, May 13, 1969.

** Water Hygiene Representative, Environmental Control Administration, Public Health Service, DHEW, Region V, Chicago, Illinois; and Commissioner representing DHEW on the Great Lakes Commission.

In 1914, the Public Health Service established and, with periodic revisions, the last in 1962, has maintained and published drinking water standards for water supplies used on interstate carriers and has responsibility for the certification of such water supplies. These standards have been adopted or are used as the guidelines for drinking water quality in nearly all of the states. The Public Health Service has also served as consultant and technical assistant to state and local health departments in their programs for safeguarding the quality of community water supplies.

Lake Superior and its tributaries are utilized as a raw water source for domestic water supplies serving approximately 200,000 persons with a daily withdrawal of over 25 million gallons per day.

These waters are also heavily used for industrial water supplies and water-borne commerce. An estimated 563 million gallons per day of Lake Superior water is withdrawn for industrial purposes. Many of the lake and sea-going vessels take on water from Lake Superior for use as a potable water supply. Public Health Service regulations allow high quality waters, such as those generally found in the Great Lakes, to be used for drinking and culinary purposes with only disinfection treatment. Studies (Report on Vessel Watering on the Great Lakes, dated December 30, 1966) of pollution of Great Lakes waters have revealed contamination in certain areas which exceed recognized limits for such treatment. Such contaminated water may pose a hazard to health. In a recent Notice to Mariners, it was recommended that: waters within five(5) miles of shore, and water within twenty(20) miles of metropolitan areas not be taken aboard for use as potable water if it is treated by disinfection only, such as chlorination.

Lake Superior is also heavily used for recreational activities such as swimming, boating, water skiing, and fishing. Protection of Lake Superior's excellent water quality for these uses is a very important aspect of this Conference.

The Michigan, Minnesota and Wisconsin surface water quality criteria were submitted to our agency for review and comments. In separate letters pertaining to each state's criteria (Re: Michigan-dated 9/20/68;

Re: Minnesota and Wisconsin-dated 1/15/69), comments were transmitted to the Federal Water Pollutional Administration. Each of the letters contained a common introduction followed by a discussion of the criteria. The introductory remarks and comments pertaining to these states are as follows:

> "Under the provisions of the Interdepartmental Agreement of September 2, 1966, we offer for your consideration the following comments on the public health aspects of the (name of state) Surface Water Quality Criteria.
>
> These comments are limited to those criteria considered important to protection of the public health and are primarily concerned with the following subjects: Discussion of Criteria and Surface Water Quality Criteria, relating to Public Water Supply and Recreation."

Discussion of Criteria (Michigan)

The Michigan Water Quality Standards are applied according to present and future use as delineated for the primary interstate water basins. The Public Health Service considers the Michigan Quality Standards to be well written and finds them, with exceptions noted below, to be consistent with Public Health Service recommendations.

Domestic Water Supply

The "acceptable treatment methods" required should be further defined as a minimum of conventional treatment including coagulation, sedimentation, rapid sand filtration, and disinfection.

Standards for boron, carbon chloroform extract, iron, pesticides and uranyl ion are omitted and should be included in the Michigan Standards. The standard for cyanide is the mandatory Public Health Service standard for finished drinking water rather than the recommended Standard. Radiological standards for Radium 226 and Strontium 90 are omitted and should be added to the Michigan Standards. Public Health Service recommendations for these chemical and radiological substances are included in Section I of the "Health Guidelines for Raw Water Quality."

Recreation

The recreation standards are considered adequate for the protection of the public health.

Discussion of Criteria (Minnesota)

"Domestic Consumption" criteria should provide standards for radioactivity in accordance with the recommendations contained in the Public Health Service "Health Guidelines for Raw Water Quality" previously submitted to your office for review. All other Minnesota standards relating to "Domestic Consumption" criteria are satisfactory.

The Minnesota standard relating to "Fisheries and Recreation," based on total coliforms, should protect the public health. On occasion, however, the standard, 1,000 coliforms per 100 milliliters, will limit recreational use of water when health hazards do not actually exist. We believe that standards based on fecal coliforms would give a more realistic guide for the evaluation of health hazards. Such standards are recommended in Section II of the Public Health Service "Health Guidelines for Raw Water Quality" previously submitted to your office for review.

Discussion of Criteria (Wisconsin)

These standards are well written and with limited additions to those sections dealing with public water supply and recreation, they are considered satisfactory with regard to public health protection.

Public Water Supply

Since food processing waters require water quality equal to that of public water supplies, food processing waters should be included in this class. For the bacterial quality specified, "appropriate treatment and adequate safeguards' should be defined as conventional treatment including coagulation, sedimentation, rapid sand filtration, and disinfection.

Limiting standards should be added for concentrations of boron, pesticides, and uranyl ion as recommended by the Public Health Service "Health Guidelines for Raw Water Quality."

Recreational Use

The bacteriological standard pertaining to water contact recreation, based on total coliforms, should protect the public health. On occasion, however, the standard of 1,000 coliforms per 100 milliliters will limit recreational use of water when health hazards do not exist. A standard

Standards for boron, carbon chloroform extract, iron, pesticides and uranyl ion are omitted and should be included in the Michigan Standards. The standard for cyanids is the mandatory Public Health Service standard for finished drinking water rather than the recommended Standard. Radiological standards for Radium 226 and Strontium 90 are omitted and should be added to the Michigan Standards. Public Health Service recommendations for these chemical and radiological substances are included in Section I of the "Health Guidelines for Raw Water Quality."

Recreation

The recreation standards are considered adequate for the protection of the public health.

Discussion of Criteria (Minnesota)

"Domestic Consumption" criteria should provide standards for radioactivity in accordance with the recommendations contained in the Public Health Service "Health Guidelines for Raw Water Quality" previously submitted to your office for review. All other Minnesota standards relating to "Domestic Consumption" criteria are satisfactory.

The Minnesota standard relating to "Fisheries and Recreation," based on total coliforms, should protect the public health. On occasion, however, the standard, 1,000 coliforms per 100 milliliters, will limit recreational use of water when health hazards do not actually exist. We believe that standards based on fecal coliforms would give a more re-based on fecal coliforms would give a more realistic guide for the evaluation of health hazards. Such a standard is recommended in Section II of the "Health Guidelines for Raw Water Quality."

The opportunity to present these reviews is appreciated.

You will note in these letters that we consider "appropriate treatment and adequate safeguards" for public water supplies and food processing waters, utilizing surface waters as their source, being defined as a minimum of conventional treatment including coagulation, sedimentation, filtration, and disinfection. Also that fecal coliform criteria for domestic water supplies and recreational uses should be included in the state's criteria.

It should be further noted that we do not consider any degree of waste treatment less than secondary to be adequate where the downstream waters are to be used for public water supply or whole body contact recreation. In our opinion, fecal coliform criteria is appropriate; these criteria should not be modified even on the basis of findings from a sanitary survey. The criteria to be used in these states should be no less stringent than the limits placed in our publication, "Health Guidelines for Raw Water Quality." These guidelines provide standards for water to be used for domestic and food processing uses, recreation, shellfish, agriculture, as well as for control measures when considering vectors or the disposal of solid wastes. To cite a few of the standards, we would like to emphasize that the total coliform density shall not exceed 20,000 per 100 milliliters as measured by monthly geometric mean or that the fecal coliform density shall not exceed 4,000 per 100 milliliters as measured by monthly geometric mean for intake water to a water treatment plant providing coagulation, sedimentation, filtration, and disinfection. For water contact recreational uses, the fecal coliform density should not exceed the geometric mean of 200 per 100 milliliters with a sampling frequency of 5 samples per 30-day period taken during peak recreational use. Not more than 10 percent of the samples' fecal coliform densities during any 30-day period should exceed 400 per 100 milliliters.

I am pleased to represent the Department of Health, Education, and Welfare at this conference. We in the Public Health Service are ready to do whatever we can to cooperate and assist in the job of safeguarding and maintaining the high quality of these waters.

MR. DOMINICK: Thank you, doctor. Will you please pass on our thanks to Dr. Marshall.

DR. WALTON: I will do that.

I also have a statement on behalf of myself, that is, in my title as Chief, Technical Services, Bureau of Water Hygiene, U. S. Public Health Service, Cincinnati, Ohio.

STATEMENT OF GRAHAM WALTON, CHIEF, TECHNICAL
SERVICES, BUREAU OF WATER HYGIENE, U. S.
PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE, CINCINNATI, OHIO

DR. WALTON: The Public Health Service is concerned with the health-related aspects of water pollution. Although the water uses with which the Public Health Service is concerned include natural waters used for bathing and for growing of shellfish, this presentation is limited to waters used for the production of public water supplies.

Those concerned with the production of "biologically safe" public water supplies generally accept the desirability of erecting multiple barriers against water serving as the agent in transmitting disease-producing organisms. These barriers include:

1. Effective treatment of sewage and other waste waters.

2. Natural purification processes which are active in surface or ground waters receiving the wastes.

3. Water treatment processes - clarification and

disinfection.

The city of Duluth, Minnesota, secures its water from Lake Superior. This water is treated by chlorine disinfection only. Continued production of "biologically safe" and "aesthetically acceptable" water requires adequate protection of the quality of Duluth's intake water.

In the manual "Public Drinking Water Supply Evaluation" (In press), which will replace the "Manual of Water Sanitation Practice" of 1946, the Public Health Service recommends permissible quality criteria for surface waters that are treated by disinfection only to produce a public water supply. This publication specifies that the total coliform density of the intake water, as measured by a monthly arithmetic mean, may not exceed 100 per 100 ml. unless fecal coliform examinations are routinely made and their density, as measured by a monthly arithmetic mean, does not exceed 20 per 100 ml.

The Minnesota Water Pollution Control Agency has established an upper limit for total coliform bacteria of 50 per 100 ml. in the open waters of Lake Superior. Both the Michigan Water Resources Commission and the Wisconsin Department of Natural Resources permit total coliform densities which do not exceed an arithmetic average of 1,000 per 100 ml. The Michigan and Wisconsin bacteriological standards would permit degradation of Lake Superior water to the point where it is no longer treatable by disinfection only to produce a public water supply.

Bacterial content of a water is not the only criteria by which the suitability of the water used to produce a public water supply is determined. Each of the three involved States and the U. S. Public Health Service specify additional criteria for source waters receiving different degrees of treatment to produce a public water supply. As the quality of Lake Superior water is such that most of these criteria are not likely to be of concern to this conference, it does not appear desirable to take the time required to discuss these additional criteria. However, I wish to submit for the record an excerpt from the Public Health Service "Manual for Evaluating Public Drinking Water Supplies" (In press), which gives quality characteristics for waters suitable with various types of treatment for production of public water supplies.

May I ask that this excerpt from that publication, which is included in the text, be included as part of the record.

MR. DOMINICK: We will receive the excerpt.

(The excerpt from the "Manual for Evaluating Public Drinking Water Supplies; A Manual of Practice Recommended by the Public Health Service" follows.)

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B. WATER TREATMENT REQUIREMENTS

1. General Requirements

The water quality requirements of the PHS Drinking Water Standards are minimum requirements, and good quality water should have physical and chemical characteristics considerably better than the limiting values established in the PHS Drinking Water Standards (Sections 4.2, 5.1, 5.2, 6.1, and 6.2). For example, water with turbidity of 5 units and a color of 15 units may be acceptable, but in a coagulated, filtered water such values could indicate serious malfunctioning of the purification process. Similarly, increased concentrations of copper and iron could indicate a corrosiveness that would be objectionable to consumers, even though the concentrations of the metals did not exceed recommended limits. In well water an increase in chlorides over the normal amount found in ground waters in the area may be the first indication of pollution.

The type of treatment required depends on the characteristics of the watershed, the raw water quality, and the desired finished water quality. If pollution of the source water is increasing, plant facilities, which were adequate for treatment of a nonpolluted water, may become inadequate. The production of water that is free from pathogenic organisms, aesthetically satisfactory to the senses, and reasonably acceptable chemically becomes increasingly difficult when the raw water has a high and varying chlorine demand, contains large numbers of coliform bacteria, or contains high concentrations of dissolved solids, toxic substances, or taste and odor producing substances.

When evaluating the ability of a water supply system to constantly produce a safe and satisfactory water, these factors should be considered:

(a) the quality of water produced at times of unusual stress, such as during heavy run-offs, periods of drought, or periods of excessive demand as shown in the records;

Excerpt from "Manual for Evaluating Public Drinking Water Supplies; A Manual of Practice Recommended by the Public Health Service," PHS Publication No. 1820 (In Press).

(b) the quality of the raw and finished waters, as determined by laboratory data and sanitary surveys, and any trends in improvement or deterioration;

(c) the purification processes, including the facilities used to apply disinfectants at various locations in the treatment process, and their capacities compared with the capacities considered necessary to meet maximum anticipated requirements;

(d) the treatment processes used and their reliability in changing raw water characteristics to produce a finished water that continuously meets the PHS Drinking Water Standards;

(e) the minimum residual chlorine concentration in the plant effluent water, when chlorine is used, together with the time that this or greater chlorine levels were maintained;

(f) the qualifications of the operators and laboratory personnel, as indicated by appropriate training, or certification, or both; and

(g) the laboratory facilities and analytical procedures, frequency and extent of their use, and application of the data to operational control.

2. Extent of Treatment

The Public Health Service recommends that all municipal water supplies, whether they be ground water or surface water, receive treatment by disinfection regardless of the quality of the water. The benefits from the added protection provided by disinfection far outweigh the increased cost and the added maintenance incurred by the water utility. When coliform density is used as one criterion for judging treatment requirements, raw waters can be divided into three groups: clean, clear, and polluted waters. The coliform densities of the raw waters can be expressed in terms of the most probable number (MPN) from the multiple-tube fermentation technique, or actual coliform counts determined by the membrane filter (MF) technique.

The requirements are given for three groups of water: those usable without treatment, those needing disinfection only, and those needing complete treatment.

Group I. Requirements for Water Usable Without Treatment

A. Bacteriological Quality: shall meet PHS Drinking Water Standards.

B. Physical Quality: should meet PHS Drinking Water Standards.

C. Chemical Quality: chemical concentrations should not exceed the following:

Substance	Concentration, mg/liter
Arsenic (As)	0.01
Barium (Ba)	1.0[a]
Boron (B)	1.0
Cadmium (Cd)	0.01[a]
Carbon Chloroform Extract (CCE)	0.2
Chloride (Cl)	250
Chromium (hexavalent, Cr^{+6})	0.05[a]
Copper (Cu)	1.0
Cyanide (CN)	0.01
Detergents (Methylene Blue Active Substances)	0.5
Fluoride (F)[b]	
50.0-58.3°F	1.8
58.4-70.6°F	1.5
70.7-90.5°F	1.2
Iron (Fe)	0.3
Lead (Pb)	0.05[a]
Manganese (Mn)	0.05
Nitrogen (nitrate plus nitrite)	10.0
Phenols	0.001
Selenium (Se)	0.01[a]
Silver (Ag)	0.05[a]
Sulfate (SO_4)	250
Total Dissolved Solids (TDS)	500
Uranyl ion (UO_2^{++})	5.0
Zinc (Zn)	5.0

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[a] Concentrations in excess of values listed shall constitute grounds for rejection of the supply.

[b] Annual average of maximum daily air temperatures.

Substances not included in the above table that may have deleterious physiological effect or that may be excessively corrosive to the water supply system should not be permitted in the raw water supply.

D. Radioactivity: should comply with the PHS Drinking Water Standards.

E. Pesticides: should not exceed the following limits:

Pesticide	Maximum permissible concentration, mg/liter[a]
Endrin	0.001
Aldrin	0.017
Dieldrin	0.017
Lindane	0.056
Toxaphene	0.005
Heptachlor	0.018
Heptachlor epoxide	0.018
DDT	0.042
Chlordane	0.003
Methoxychlor	0.035
Total organophosphorous and carbamate compounds[b]	0.1
2,4,5-TP 2,4,5-T 2,4,-D[c]	Individual limits = 0.1 mg/liter; Sum of any combination of chlorinated phenoxy aklyl pesticides = 0.1 mg/liter

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[a] For long term exposure.

[b] Expressed in terms of parathion equivalent cholinesterase inhibition.

[c] Short period limit only: 2 to 3 days, no more than once or twice a year.

Group II. Requirements for Water Needing Disinfection Only

A. Physical, Chemical, Radioactivity, and Pesticide Requirements: the requirements as shown for untreated raw ground water (Groups I.B, I.C, I.D, and I.E) should be met. If the water does not consistently meet all these requirements, consideration should be given to providing additional treatment during periodic decreases in quality that result from high turbidity, tastes, etc.

B Bacteriological Quality:

1. Total Coliform Density: Less than 100 per 100 milliliters as measured by a monthly arithmetic mean.
2. Fecal Coliform Density: If fecal coliform density is measured, the above total coliform density may be exceeded, but fecal coliform density should not, in any case, exceed 20 per 100 milliliters as measured by a monthly arithmetic mean. When the fecal coliform vs. total coliform criterion is used for Group II water, the fecal coliform count should never exceed the 20 per 100 milliliters monthly arithmetic mean. This fecal coliform standard only applies when it is being measured on a regular basis.

Group III. Requirements for Water Needing Treatment by Complete Conventional Means Including Coagulation, Sedimentation, Rapid Granular Filtration, and Disinfection (Pre and Post)

A. Bacteriological Quality:

1. Total Coliform Density Less than 20,000 per 100 milliliters as measured by a monthly geometric mean or.
2. Fecal Coliform Density: If fecal coliform density is measured, the above total coliform density may be exceeded, but fecal coliform should not exceed 4,000 per 100 milliliters as measured by a monthly geometric mean.

The same rationale applies here as in the Group II waters concerning the use of the fecal coliform vs. total coliform criterion. In no case should the fecal coliform count exceed the 4,000 per 100 milliliters monthly geometric mean.

The arithmetic mean is used with the Group II waters because the bacteriological data from these waters will be of lesser magnitude than that from the Group III waters; this difference in magnitude between the monthly means of the Group II and Group III waters is best reflected by the arithmetic and geometric means, respectively.

These bacteriological limits may possibly be exceeded if treatment (in addition to coagulation, sedimentation, rapid granular filtration, and disinfection) is provided and is shown to be doing a satisfactory job of providing health protection.

B. Physical Quality: Elements of color, odor, and turbidity contribute significantly to the treatability and potability of the water.

1. Color: A limit of 75 color units should not be exceeded. This limit applies only to nonindustrial sources; industrial concentrations of color should be handled on a case-by-case basis and should not exceed levels that are treatable by complete conventional means.
2. Odor: A limit of 5 threshold numbers should not be exceeded.
3. Turbidity: The limits for turbidity are variable. Factors of nature, size, and electrical charge for the different particles causing turbidity require a variable limit. Turbidity should remain within a range that is readily treatable by complete conventional means. It should not overload the water treatment works, and it should not change rapidly either in nature or in concentration when such rapid shifts would upset normal treatment operations.

C. Chemical Quality: Since there is little reduction in chemical constituents with complete conventional treatment, raw water should meet the limits given for Group I.C.

D. Radioactivity: Should comply with PHS Drinking Water Standards.

E. Pesticides: Should comply with requirements for pesticides as shown for untreated raw ground water in Group I.E.

Infectious material, the increasing diversity of chemical pollutants found in Group III raw waters, and the many different situations encountered in regional and local problems make it impractical to prescribe a limited selection of facilities and processes that can effectively handle all problems presented by raw water and its sources. Future improvements in treatment technology cannot be reasonably assisted or regulated by requiring the fixed process steps considered good for today's technology. Table 1 describes some factors that increase the difficulty in securing disinfection, e.g., adequate disinfection with halogens depends on temperature, pH, contact time, and concentration of disinfectant.

Table 1. CONDITIONS CREATING DIFFICULTIES AT THE WATER PLANT AND IN THE WATER MAINS

Bacterial and biological conditions	Chemical conditions	Physical and operational conditions
Increasing numbers of coliforms	Ammonia nitrogen	Low temperature
Biological pollution, i.e., algal or fungal metabolic products that effect chlorine demand	Toxic materials or taste and odor requiring removal	Extended distribution systems
Filter clogging organisms that effect chlorine demand	Color or organic dispersing agents (anticoagulants), lignin compounds	Highly variable water quality
	Chlorine demand	Rapid variation in flow and turbidity of surface water resource
	Iron and manganese	Tidal effects
	High organic content	
	~~High or organic content~~	
	High or fluctuating pH	

Types of disinfection other than chlorination must be demonstrated to function effectively in all compositions of water likely to be encountered from the source used. If a distribution system is of any considerable length, the disinfection method should provide a residual protection that can be easily measured.

Where water sources show continuing quality deterioration or the quality of water available is not adequate for future demand, the water purveyor should be examining alternate or auxiliary sources of supply and should have positive plans to procure adequate facilities and sources.

Graham Walton

The treatment of water by disinfection only, as practiced by the city of Duluth, involves the use of chlorine or chlorine compounds to destroy or inactivate pathogenic and other microorganisms. The effectiveness of chlorine disinfection varies with the organisms involved, the time of chlorine contact, the form and concentration of residual chlorine, and the temperature, pH, and turbidity of the water. With one exception, that of turbidity -- its amount and composition -- the effects of these variables have been the subject of numerous laboratory investigations. Chlorination, as shown by laboratory studies, can, when properly performed, effectively destroy or inactivate most pathogenic organisms. Most of these studies, however, have been made using water essentially free from turbidity.

Effective disinfection is more difficult if a water contains appreciable turbidity; suspended inorganic and organic materials may protect organisms adhering thereon or embedded therein. Sanderson and Kelly in their discussion of the paper "Human Enteric Viruses in Water: Source, Survival, and Removability" (Clarke et al., 1964) noted that bacteriological examinations of a water chlorinated to provide 0.1 to 0,5 mg/l free residual chlorine after not less than 30 minutes contact consistently yielded confirmed coliform bacteria. They attributed the survival of these bacteria to the bacteria being embedded in the turbidity-producing particles in a manner protecting them against contact with chlorine. Tracy et al. (1966) reported on the persistence of coliform bacteria in San Francisco water. These authors attributed their findings -- the detection of coliform bacteria in water chlorinated to provide substantial chlorine residuals after hours of contact -- to the coliform bacteria surviving in the bodies of crustacea. Walton (1961) analyzed data from three waterworks treating surface waters by chlorination only. It may be significant that coliform bacteria were detected in the chlorinated water at only one waterworks, which treated a Great Lakes water that occasionally contained high turbidities.

The continued use of Lake Superior as a source for production of public water supplies treated by chlorination, only requires adequate control of its bacterial density, turbidity, and other pollutants that would result in an unsatisfactory domestic water supply.

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Thank you, Mr. Chairman.

MR. DOMINICK: Thank you, Dr. Walton.

I think we have some questions.

MR. PURDY: I have a question.

MR. DOMINICK: Mr. Frangos, do you have a question?

MR. FRANGOS: Let Mr. Purdy and then I will go.

MR. DOMINICK: Mr. Purdy.

MR. PURDY: Yes. You refer to the health bulletin for raw water quality. Is that a part of the 1962 Drinking Water Standards?

DR. WALTON: No, it is not, any more than the original one.

MR. PURDY: I would also like to draw your attention to Page 3 of your statement. It does not --

DR. WALTON: (interrupting): Of my statement or Marshall's?

MR. PURDY: Page 3 of your statement.

It does not accurately reflect the standards that have been adopted by the State of Michigan. I am sure that Wisconsin and Michigan can speak to that point.

DR. WALTON: In what way, please?

MR. PURDY: "...Michigan and Wisconsin bacteriological standards would permit degradation of Lake Superior water to the point where it is no longer treatable by disinfection only to produce a public water supply."

Michigan, along with the other States that have approved interstate water quality standards, has adopted as a part of their standard -- a standard that has been approved -- a statement to protect waters that are of higher quality than the numerical designations of the standards. So I suggest that the standards, as adopted by the State of Michigan, would not allow a degradation of the Lake Superior water which would affect the public water supply.

DR. WALTON: If I misinterpreted this it is because you used the information in the release from the Federal Water Pollution Control, the tables showing the control --

MR. PURDY (interrupting): All of the States there have been required to adopt as a part of their standards program a statement to protect high quality waters and those are not shown in the tables.

That is all that I have.

MR. FRANGOS: Dr. Walton, I am trying to find in Mr. Marshall's statement, I believe it is on Page 3, about the notice to the mariners with respect to water that should be taken onboard for drinking water. I am wondering if you can tell us of any efforts of your Agency to cover the reverse of this, and that is the potential threat to the public health that is caused by navigation -- shipping in the Great Lakes -- when they come into proximity of the public water supply intakes.

DR. WALTON: This has not been an area of my activity. I do not feel that I am in a position to answer your question, I am sorry.

MR. FRANGOS: But you do recognize that this is certainly a problem?

DR. WALTON: There is no question, particularly with the large boats and even with the small pleasure craft, it is a problem. I am not too familiar with the activity of this kind on the Great Lakes.

MR. BADALICH: I have one question, also.

Regarding the health guidelines for raw water quality, I believe Mr. Purdy mentioned this also. On Page 5 are these guidelines -- have they been adopted by the Public Health Service or the Department of Health, Education, and Welfare?

DR. WALTON: They are essentially the same general values that are appearing and I would be glad to leave these copies --

MR. BADALICH (interrupting): Are they of the same type of regulation, 1962, No. 956 that we make reference to in our Water Quality Standards?

DR. WALTON: I am not quite sure what that is. The health guidelines are criteria that are established for various types of waters receiving various types of treatment, and also recommendation for future Public Health Service Drinking Water Standards.

MR. BADALICH: But it is not adopted as a regulation at this time?

DR. WALTON: No, it has no official standing. It is a recommendation, in a sense, but it has not received official standing. You will find those same criteria in the publication that I mentioned that I am inserting in the record, so it becomes a recommendation, I would say; you might say an official recommendation. It is only a recommendation.

MR. BADALICH: So, I take it, the publication 956 contains no regulations with respect to radioactivity, because we have adopted this regulation in its entirety, including all amendments, revisions, etc.

MR. WALTON: Yes, I think you are probably right. I am not sufficiently informed of that.

MR. BADALICH: Speaking of radioactivity, I think the State of Minnesota is well versed in this subject.

MR. WALTON: O.K.

MR. DOMINICK: Dr. Walton, we will put your excerpt from the "Manual for Evaluating Public Drinking Water Supplies" into the record at the point that you offered it.

MR. WALTON: Thank you.

MR. DOMINICK: Do we have any other Federal, governmental witnesses, any State or local witnesses who have not been heard from?

(No response.)

MR. DOMINICK: Do we have any other governmental statements which might be submitted for the record?

(No response.)

MR. DOMINICK: Very well. We will adjourn and meet here at 1:30 p.m.

(Whereupon, at 12:15 p.m. the conference recessed for lunch.

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